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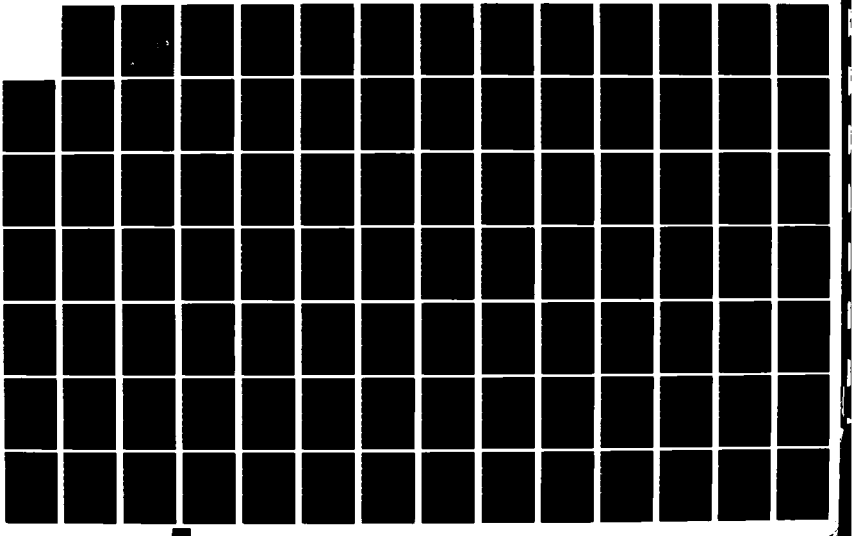

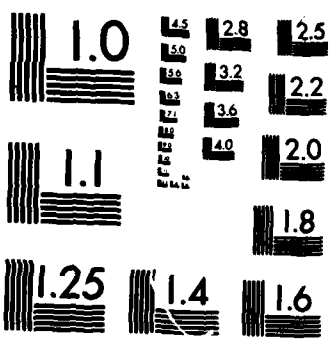

BY THE COMPTROLLER GENERAL

Report To The Committee On Foreign Affairs House Of Representatives OF THE UNITED STATES

Chemical Warfare: Many Unanswered Questions

The current debate on whether the United States should increase its chemical warfare capability usually involves one or more of these questions:

- **--How can chemical warfare be deterred?**
- **--How do U.S. and Soviet chemical warfare capabilities compare?**
- **--How can the United States modernize its chemical warfare system?**
- **--How will modernization affect the prospects for disarmament?**

GAO assessed the nature, extent, and quality of the information that is available for answering these questions. This is an unclassified report: its classified version is published under the number GAO/C-IPE-83-1.

UNITED STATES GENERAL ACCOUNTING OFFICE

GAO/IPE-83-6
APRIL 29, 1983

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON D.C. 20548

B-211376

The Honorable Clement J. Zablocki
Chairman, Committee on Foreign Affairs
House of Representatives

Dear Mr. Chairman:

Enclosed is our report responding to your March 18, 1982, letter. You asked that we assess and synthesize the currently existing information describing deterrence against the use of chemical weapons, Soviet and U.S. chemical warfare capabilities, binary chemical weapons, and the implications of binary weapons production for disarmament negotiations. This is an unclassified version of our classified report numbered GAO/C-IPE-83-1.

Officials of the Department of Defense reviewed a draft of this report and provided written and oral comments. Their written comments and our responding letter are included in the report as appendix IV.

Copies of this report are being sent to other interested congressional committees; the Secretaries of State, Defense, Army, Air Force, and Navy; and the Director of the Office of Management and Budget.

Sincerely,

Charles A. Bowsher

Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO THE COMMITTEE ON
FOREIGN AFFAIRS
HOUSE OF REPRESENTATIVES

CHEMICAL WARFARE: MANY UNANSWERED QUESTIONS

D I G E S T

Controversial issues have been raised by the present Administration's plan to spend between $6 billion and $7 billion in 1983-87 to modernize the U.S. defensive and retaliatory chemical warfare capabilities. The House Committee on Foreign Affairs asked GAO to assess and synthesize the nature, extent, and quality of the documented information that relates to these questions: (1) How can chemical warfare be deterred? (2) How do U.S. and Soviet chemical warfare capabilities compare? (3) How can the United States modernize its chemical warfare system? (4) How will modernization affect the prospects for disarmament? The current debate on whether the United States should increase its chemical warfare capability necessarily involves these questions.

OBJECTIVES, SCOPE, AND METHODOLOGY

This report is an "information synthesis." GAO examined the facts and analyses that support the various positions that have been taken on chemical warfare issues, assessed the confidence that can be placed in that information, and identified the gaps and inadequacies that it presents. GAO reviewed and assessed classified (up to and including secret) and unclassified literature, focusing on empirical and analytical studies, including Department of Defense (DOD) technical documents. GAO used various techniques and experts' assistance to ensure the inclusion of all the major information sources in its review. GAO also interviewed experts representing a wide range of positions in the chemical warfare modernization debate. The end product of these efforts provides a synthesis of what is currently known about the chemical warfare issues under study. The report identifies the information that GAO finds adequately substantiated and the gaps and inadequacies that remain in that information.

SUMMARY OF GAO'S FINDINGS

GAO finds that most arguments about chemical warfare are based on belief rather than on empirical

Tear Sheet

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evidence. Much of the information presented as fact is unsupported by citations. Few simulations and test-and-evaluation studies have been performed. Several GAO reports have been issued in the past that identify deficiencies in U.S. chemical warfare defensive and retaliatory readiness.

In the present review, GAO identified a multitude of unanswered questions about chemical warfare, some having been partly, but inadequately, addressed and some having, apparently, not even been raised. GAO finds that the U.S. chemical weapon system is generally not seen as a credible deterrent and that little is known about its functioning or its usefulness. Yet the U.S. Department of Defense is requesting a large amount of money to modernize it. GAO is particularly concerned about DOD's modernization program because so many questions have not been satisfactorily answered, even though the United States has continued to maintain chemical weapons.

HOW CAN CHEMICAL WARFARE BE DETERRED?

The general concept of deterrence is that potential adversaries can be dissuaded from hostile actions if they perceive a nation as being both able and willing to retaliate against aggression with a means that can inflict unacceptable damage. Chemical warfare analysts differ, however, on what means are most likely to inflict (and to be perceived as likely to inflict) unacceptable damage. Two views are most often expressed--(1) that the threat of tactical nuclear response is a credible deterrent to chemical warfare and (2) that the ability to retaliate with chemical weapons is necessary in deterring chemical warfare. (pp. 12-13)

The literature reveals three overlapping ways of achieving chemical warfare deterrence:

--arms control: an acceptable treaty banning chemical warfare would reduce the need for chemical weapons and the risk of a chemical attack;

--weapons: a major conventional, nuclear, or chemical warfighting ability would achieve chemical deterrence;

--defense: an adequate defensive position against a chemical attack would reduce the likelihood

of such attack and the need for a large chemical retaliatory capability.

All three require some defensive capability, and policies emphasizing weapons and defense call for some retaliatory capability. (pp. 15-17)

The literature shows that U.S. policy reflects either an emphasis on weapons or an emphasis on defense with a limited retaliatory capability. It also shows that the United States has consistently stated a policy of retaliating in kind--that is, responding with chemical weapons to a chemical attack. The existence of the U.S. chemical weapons arsenal and current proposals to upgrade its defensive and retaliatory capabilities confirm and expand--but do not change--this policy. (pp. 17-18)

HOW DO U.S. AND SOVIET CAPABILITIES COMPARE?

The U.S. chemical warfare deterrence policy requires both chemical retaliatory and defensive, or protective, capabilities. The literature agrees in general that the United States lacks a credible chemical warfare deterrent. Inadequacies in the U.S. ability to retaliate and defend are well documented.

In contrast, the literature generally reflects the perception that the Soviet Union is highly capable of waging chemical war. Classified and unclassified documents supply only limited information to support the various assertions that are made about the specific levels of Soviet offensive capability. However, available facts do support assertions that the Soviets have built a strong ability to defend against nuclear, biological, and chemical warfare. (pp. 20-52)

The findings and gaps in the literature on how the United States and the Soviet Union compare on five elements of capability--doctrine, stockpile, delivery systems, defense equipment, and implementation--can be summarized in the following way.

1. Even though the United States does not have a chemical warfare doctrine implementing its policy, DOD is preparing to modernize the U.S. chemical weapons arsenal. There is evidence that the Soviet Union has developed defensive doctrine for integrated conventional, nuclear, and chemi-

cal warfare; less is known about Soviet offensive doctrine. (pp. 20-26)

2. The precise size and condition of the U.S. chemical stockpile are not known, but it is known that the stockpile provides only a limited long-range air-strike capability and no long-range surface-to-surface capability at all. Little is known about the size and mixture of the Soviet stockpile of chemical munitions. (pp. 26-35)

3. The United States appears to have no plan for developing a long-range surface-to-surface chemical weapons delivery system. The Soviet system for delivering chemical warfare agents seems well developed, but little is known about its specific capabilities. (pp. 35-39)

4. In developing defensive equipment, the United States has put into the field relatively good suits for individual protection but needs to improve decontamination, remote-area detection, and collective protection in vehicles and stationary shelters; remote sensors and alarms are an especially critical deficiency. The Soviets have made extensive chemical warfare defensive preparations in all areas--decontamination, detection, and individual and collective protection. (pp. 39-49)

5. Regarding implementation, the United States has not pursued initiatives with its NATO allies that would allow forward deployment of chemical weapons, and logistics plans for timely deployment in Europe are not in evidence. Little is known about Soviet chemical weapons deployment. (pp. 50, 59-60)

HOW CAN THE UNITED STATES MODERNIZE ITS CHEMICAL WARFARE SYSTEM?

There are alternative ways to modernize U.S. chemical warfare deterrence capability. DOD should have adequate information on them, a strong rationale based on reliable data for selecting one alternative rather than another, and comprehensive and integrated plans for improving the five elements of capability. DOD's modernization plans do not present convincing evidence that these requirements have been adequately met. (pp. 75-76)

The production of binary weapons is the centerpiece of the U.S. modernization program. DOD's

plans for 1983-87 would augment the existing stockpile of unitary weapons with new binary weapons. A binary weapon keeps nonlethal chemicals separately in two canisters until the time of using the weapon, when the canisters are brought together in an artillery shell or a bomb and the nonlethal chemicals are mixed, producing a lethal agent. (pp. 67-69)

DOD's program is based on the assumption that existing unitary chemical weapons are insufficient in number and condition. Opponents of DOD's binary program do not accept this assumption. They assert that the existing stockpile of unitary chemical weapons would provide an adequate retaliatory capability if it were refurbished and maintained. GAO finds that present knowledge is not adequate either to refute or to support the assumptions, claims, and counterclaims in this debate. (pp. 61-67)

GAO finds that assertions about the specific technical and operational advantages of binary weapons, compared with unitary weapons, are not supported by empirical evidence and must be recognized as possibly inaccurate. The lack of field-test data on binary weapons leaves a substantial gap in what is known about them, and many have challenged the credibility of the simulation data. There is some consensus that the design of binary weapons makes them safer than unitary weapons for handling, storing, and transporting in peacetime, but these peacetime advantages may have some related wartime costs (such as mixing time and more complex logistics) that are not often discussed. Various alternatives to the production of binary weapons are described in the literature, but few studies have attempted to determine their relative merits or what would happen if they were used in a chemical war. (pp. 61-75)

HOW WILL MODERNIZATION AFFECT THE PROSPECTS FOR DISARMAMENT?

GAO finds two major positions on how the U.S. chemical warfare modernization program might affect prospects for disarmament. One view is that modernizing by producing binary weapons would result in a negotiations breakthrough; the other view is that it would have the opposite effect and result in a total breakdown of negotiations and an arms race. Data and analyses supporting these positions are few. A major

stumbling block in current disarmament negotiations is on-site verification of chemical warfare-related activity. The literature suggests that binary production might complicate verification procedures. (pp. 86-90)

CONCLUDING OBSERVATIONS

Conjecture plays a major role in the formulation of theories about chemical warfare deterrence and in the analysis of Soviet threats and possible U.S. responses. There is little empirical data on the functioning and usefulness of chemical weapons. GAO finds seven areas of primary information need. (pp. 102-03)

1. Soviet offensive capability: More reliable information is needed on Soviet offensive capability. The evidence is strong that the Soviets have been building nuclear, biological, and chemical defensive capabilities, but this does not necessarily imply, as is sometimes assumed, that the United States should strengthen its chemical retaliatory capabilities.

2. Combination of chemical and nonchemical munitions: The literature reveals no analysis of what proportions of chemical to nonchemical munitions would be needed to remove the potential advantage of an enemy's using chemical weapons and to degrade an enemy's performance in chemical war. It is argued reasonably in the literature, however, that some ability to retaliate with chemical weapons is required.

3. Achieving military objectives: The literature does not conclude that chemicals are tactically more advantageous than other weapons in achieving military objectives, other than for achieving degradation of an enemy's performance. There appears to be no comparative information on the ability of chemical and other weapons, alone or in combination, to cause casualties in attacks on specific battlefield targets. Further, a simulation study sponsored by the Joint Chiefs of staff (JCS) indicates that under certain conditions achieve the military objective. Involvement of to achieve the objective, regardless of other combat factors. This question about a chemical , and the associated costs, requires further analysis.

4. Delivery systems: Comparative analyses of the effectiveness of the various chemical weapons delivery systems have not been made. The literature is confined to concern about reliance on limited long-range air-to-ground capability.

5. Protecting civilians: There are no analyses of how to protect the civilian population in a combat area, even though a simulation sponsored by the JCS indicates that a relatively

in a chemical war. No policies for protecting civilians have been stated.

6. Planning: The literature indicates that a major reason that chemicals have been used in only limited ways in past wars is that chemical warfare has never been assimilated into armed forces procedures, preparing everyone on the battlefield to know what to do, how to do it, when to do it, and what will happen if it is done.

7. Producing binary weapons: Given the implications for national security and for dollar expense in DOD's proposal to modernize the U.S. chemical warfare capability by producing binary weapons, the literature contains surprisingly little analysis of the advantages and disadvantages of these weapons compared with the unitary weapons they would replace. What is known about the ability of other countries to produce binary nerve agents and munitions should be brought up to date in a way that addresses the issue of verification in the negotiation of a weapons ban.

AGENCY COMMENTS AND GAO'S RESPONSE

DOD reviewed a draft of this report and provided oral and written comments. DOD was highly critical of the report, arguing that (1) a literature review is not an appropriate method for dealing with such a complex topic, (2) not all available documentation was included in the review, and (3) knowledgeable and responsible DOD officials were not interviewed. GAO's methodology goes

far beyond a literature review and GAO has revised the report to elaborate on its "information synthesis" approach. GAO remains confident that all major completed studies were included in the review and that appropriate, responsible individuals were interviewed. DOD provided no titles of studies omitted from GAO's review. Discussion of DOD's comments and GAO's response is presented in chapter 6 of the published report. DOD's written comments and GAO's letter response are included as appendix IV.

Contents

ABBREVIATIONS

ADPA	American Defense Preparedness Association
DIA	Defense Intelligence Agency
DOD	U.S. Department of Defense
DSB	Defense Science Board
GAO	U.S. General Accounting Office
IDA	Institute for Defense Analyses
JCS	Joint Chiefs of Staff
SIPRI	Stockholm International Peace Research Institute
SRI	Stanford Research Institute

CHAPTER 1

INTRODUCTION

Claiming Soviet superiority in all aspects of chemical warfare as well as the failure of years of bilateral negotiations aimed at banning chemical weapons, the U.S. Department of Defense (DOD) requested a fiscal year 1983 appropriation of $705 million from the Congress for its chemical warfare program. Although this figure is up sharply from the 1978 chemical warfare budget of $111 million and the 1981 budget of $259 million, it does not tell the whole story of the effort to overhaul the U.S. chemical warfare program. DOD has a 5-year plan for increasing the U.S. chemical warfare capability from 1983 to 1987, and its estimate of the total price tag is $6 billion to $7 billion. Other estimates run up to $14 billion for the next decade. With billions of dollars at stake in an area where emotions run high, controversy naturally has been acute. As a result, expectations about the proposed plan range from spending billions of dollars unnecessarily or even harmfully to endangering the security of the United States and its European allies if the money is not spent.

We were asked by the House Committee on Foreign Affairs to look into some of the issues that underlie the current debate on the need to increase the U.S. chemical warfare capability. In this report, therefore, we assess and synthesize the information that is available for addressing four issues of particular concern to the Committee:

--the different ways of deterring chemical warfare,

--the comparability of the United States and the Soviet Union in chemical warfare capability,

--the options for modernizing the present U.S. chemical warfare system, and

--the likely effects of modernization on the prospects for disarmament.

We describe the nature and extent of the information that is available on each topic, determine the best sources for addressing each topic, and discuss the general level of confidence we have in the findings. We also identify gaps and inadequacies in our knowledge and raise questions that remain to be addressed. Given the considerable number of unknowns that continue to exist in this area, refining and pinpointing the precise nature of these questions was a major effort.

REVIEWING THE CHEMICAL WARFARE DEBATE

Chemical warfare uses weapons that disperse incendiary mixtures, smoke, or irritating, burning, or asphyxiating gas.

Chemicals have been used in warfare throughout history, but the participants of World War I witnessed the first and last large-scale use of chemicals on the battlefield. During that encounter, the Allied forces, in an effort to build up world opinion against Germany, embarked on a campaign against chemicals, calling their use "barbarous" and "inhumane." The campaign contributed to a public objection to chemical warfare that still exists today.

The moral revulsion to chemical warfare that arose in World War I led to the Geneva Protocol of 1925, which prohibits the use of asphyxiating, poisonous, and other gases in war. The Protocol also banned biological (or bacteriological) warfare, even though biological weapons had not been used in any significant sense. Most signatories of the Protocol added a provision that they would not be bound by it if an enemy used gas or biological agents against them first. Many gases are stockpiled today, even though the stockpiling of biological weapons was banned by international agreement in the 1972 biological warfare convention.

While there have been numerous allegations that chemicals have been used in international conflicts over the past 6 decades, few have been substantiated. In all the substantiated cases, lethal chemical weapons were used against an enemy known to be deficient in antigas protective equipment or retaliatory capability.

The United States maintains the ability to retaliate in kind should an enemy use chemical weapons first. However, partly because of an open-air test accident that killed more than 6,000 sheep, and partly because of public concern about the effect on the environment of transporting and disposing of chemical weapons, legislation was enacted in 1968 that restricted the movement of chemical munitions and agents in peacetime and the development of new weapons where open-air testing is required. At about the same time, there was also a wave of adverse public opinion over the use of riot control agents (tear gas) and herbicides during the Vietnamese War, contributing further to the deemphasis of U.S. chemical warfare capabilities. The United States has produced no chemical weapons of any kind since 1969 and has been restrained from testing its stockpile since 1968. Many believe that the U.S. chemical warfare capability has become inadequate over this rather lengthy period of time.

Meanwhile, the Soviet Union has been under no similar restrictions. Also, some have charged that the Soviets have violated the international agreement not to develop, produce, or stock biological weapons and that they have encouraged and abetted the use of chemicals in Southeast Asia and Afghanistan.

It is against this background that the need to increase the U.S. chemical warfare capability is being debated. We have not

been silent on the subject, having produced six reports since 1977 on lethal chemical warfare. In 1977, we looked at the condition of the U.S. stockpile of lethal chemical munitions and agents (GAO, 1977c), and in 1981 we reviewed the status of DOD's implementation of our recommendations concerning the stockpile (GAO, 1981).[1] Also in 1977, we examined the U.S. lethal chemical munitions policy in terms of issues facing the Congress (GAO, 1977b), and in 1979 we updated that report with a fresh look at the status of issues facing the Congress (GAO, 1979). Again in 1977, we reviewed U.S. chemical warfare defense, looking at both readiness and costs (GAO, 1977a), and in 1982 we again investigated the readiness of U.S. forces, equipment, and facilities to survive and recover from a chemical attack (GAO, 1982). In the present report, we draw upon our earlier reports, especially our 1982 readiness review, but with considerably different objectives, scope, and methodology.

OBJECTIVES, SCOPE, AND METHODOLOGY

The House Committee on Foreign Affairs specifically asked us to synthesize and assess existing information on questions related to (1) deterrence against the use of chemical weapons, (2) Soviet and U.S. chemical warfare capabilities, (3) U.S. chemical warfare modernization, and (4) the likely effect of modernization on the prospects for disarmament. Debates about chemical warfare usually discuss one or more of these topics. We analyzed and synthesized information on chemical warfare to determine what is known about it, the confidence we can have in this information, and the gaps and inadequacies that remain. Thus, our objective is to assess and synthesize the rapidly accumulating information on chemical warfare relevant to these topics.

Our method with regard to documents has had four steps. First, we developed study questions on chemical warfare, basing them on the Committee's request and organizing them in a logical sequence. Second, we identified and collected our information sources (a term that we use interchangeably with the word "document"). Third, we assessed the information, classifying each source according to the study questions it addresses and the type of information it presents. When it was appropriate, we also reviewed the overall quality of the information. Fourth, in the synthesis, we determined which information is best for addressing each question, indicated the general degree of confidence that can be attributed to the findings, and identified remaining information gaps or inadequacies. In table 1 on the next page, we present an overview of our methodology and link it to the report's contents.

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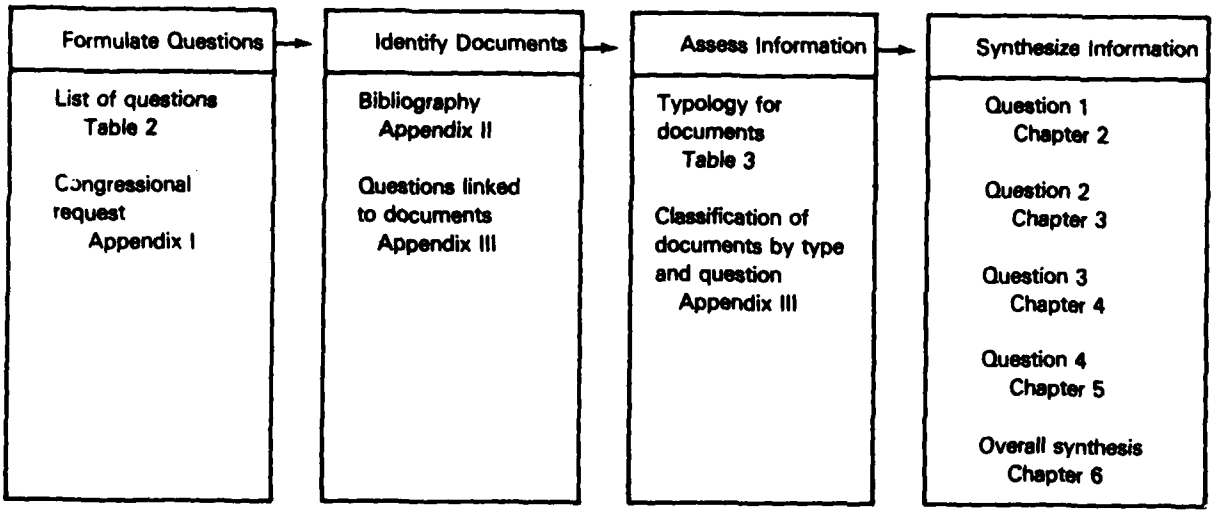
[1]Interlinear bibliographic citations are given in full in appendix II. The names of authors that are agencies are abbreviated, as here.

Table 1

An Overview of the Methodology and a Map of This Report



Along with this effort regarding documentation, we undertook several supplementary and complementary activities. We conducted interviews with a wide range of experts. We attended briefings and congressional hearings on issues related to chemical warfare. We performed these activities throughout the duration of the project. We used the results of these efforts to inform each step of our review. The review was performed in accordance with generally accepted government audit standards.

Formulating the study questions

Developing the questions of interest to the Congress on chemical warfare, we began with the four basic questions in the chemical warfare debate: (1) How is deterrence against the use of chemical weapons achieved? (2) How do the United States and the Soviet Union compare in their chemical warfare capabilities? (3) How can the United States modernize its present chemical warfare system? (4) What are the likely effects of modernization on the prospects for disarmament? As we show in table 2, we divided each question into several others. While the list is not exhaustive, each question is undeniably important to a comprehensive analysis of the chemical warfare debate. In the table, we have marked the specific questions the Committee asked with an asterisk. The Committee's letter is reprinted in appendix I.

Identifying the information sources

The controversy surrounding chemical warfare is reflected in the tremendous amount of popular and other literature that

Table 2
Chemical Warfare Questions and Subquestions [a]

QUESTION	SUBQUESTION
1.0 How is chemical warfare deterred?	1.1 What is a credible deterrence capability? 1.2 What are the different ways of deterring chemical warfare?* 1.3 How has the United States chosen to pursue deterrence?*
2.0 How do the United States and the Soviet Union compare in chemical warfare capability?	2.1 What are the U.S. and Soviet doctrines governing the use of chemical weapons?* 2.2 How does the U.S. chemical stockpile compare with the Soviet Union's and how is stockpile need determined?* 2.3 How do the U.S. and Soviet chemical warfare delivery systems compare?* 2.4 How do the United States and the Soviet Union compare in defensive equipment and personnel?* 2.5 How and to what extent have the United States and the Soviet Union prepared for implementation?*
3.0 How can the United States modernize its chemical warfare system?	3.1 What factors are necessary for modernization? 3.2 What are the alternatives to binaries?[b]* 3.3 Do binaries have substantial advantages over unitaries?*
4.0 How does modernization affect the prospects for disarmament?	4.1 How successful have chemical warfare disarmament efforts been? 4.2 What are the verification problems in banning chemical weapons?* 4.3 What implications does modernization have for disarmament?*

[a] Questions marked with an asterisk (*) were specifically raised for review by the House Committee on Foreign Affairs.

[b] Instead of containing actual nerve gas, binary weapons contain two relatively nontoxic chemicals in separate canisters that are allowed to mix and react only when the munition is being delivered to its target (or being readied for delivery), the chemical combination being a nerve gas.

has been written on it. There are literally hundreds, if not thousands, of newspaper items and editorials, popular magazine articles, technical journal articles, books, studies, and reports on chemical warfare. It was clear at the outset that our review of the literature could not be exhaustive, but it was less clear whether we wanted to be comprehensive or representative in our readings, how we would know whether we had been comprehensive or representative, and whether we would vary our approach for the different types of information.

Given our study approach and our purpose of separating fact from fiction, we focused on the information sources that would be the most likely to contain either original data or original arguments about chemical warfare. Therefore, sources such as newspaper items and popular magazine articles are underrepresented in our sample. We concentrated on articles in military and technical journals and on research studies and reports. While we looked at testimony in congressional hearings on chemical warfare, we were more interested in reviewing the sources on which the testimony had been based. We examined classified literature in addition to open literature. Our use of intelligence data in assessing Soviet capability is described in chapter 3.

To identify the relevant literature, we used chemical warfare bibliographies and reference lists as we encountered them, searched the literature, and conducted interviews. We reviewed the chemical warfare files of the Congressional Research Service and asked the Defense Technical Information Center, the Defense Logistics Studies Information Exchange, and SCORPIO to search the literature. We interviewed representatives of the U.S. Army's nuclear and chemical directorate and representatives of the Office of the Secretary of Defense and the Arms Control Disarmament Agency.

Following these procedures, we identified a large number of technical reports and articles on chemical warfare. The Defense Technical Information Center search, for example, provided a list of about 250 unclassified technical reports on chemical warfare, although we did not review them all. If a report concentrated on an area that was not a focus of one of our questions, such as demilitarization, we did not review it. If we had several recent references on a topic, we did not review all the older references. When we followed up on reference lists, we concentrated on items that were cited frequently and on items that appeared to focus on study questions for which we had limited information. Thus, we attempted to be comprehensive in our search of the literature and selective in our review and analysis. We completed our selection of documents in May 1982.

We relied on expert opinion to confirm that the final list of references that we reviewed does in fact represent the literature available for addressing the study questions. Toward this end, we asked five experts to review a draft of our bibliography

and indicate additional sources that contain factual information or arguments not accounted for in it. The experts, who take different positions in the debate on chemical warfare modernization, were Niles Fulwyler (then head of the U.S. Army's nuclear and chemical directorate), Amoretta Hoeber (Principal Deputy Assistant Secretary of Research and Development for the U.S. Army), Matthew Meselson (professor at Harvard University), John Erickson (professor at the University of Edinburgh), and J. Perry Robinson (professor at the University of Sussex). In general, these experts confirmed that our bibliography is representative, and we added references suggested by their reviews.

The bibliography of documentary sources we used to address the study questions is in appendix II. We have arranged the references in the following categories: reports by congressional agencies and organizations, military and technical journal articles, other military publications, publications by other organizations, conference papers and testimony, and books by individuals.

Assessing the information

Once we had identified the sources of information for each question, we classified them by type and by the questions they addressed. Then we made judgments about the quality of the information according to a set of assessment criteria. Later in the synthesis step, these judgments about type and quality helped us determine our confidence in the information. This, in turn, determined whether and how we used each information source.

Classifying information sources by type and by questions addressed

We classified each document we reviewed by type and by the questions it addressed. We defined eight types, which we have listed in table 3 on the next page. We also classified each document by the four study questions and their subquestions listed in table 2. In appendix III, we have displayed this classification of the information sources. Each document is classified by only one type but shares several questions with other documents.

We found that the types of information that are available differ considerably. For example, some reports give accounts supporting a particular stance on a chemical warfare issue and raising major points of controversy. Others merely identify the points of controversy in a neutral way, attempting not to take a stance on any issue. Still others describe complex simulations of scenarios of real-life situations, and yet others report on tests and evaluations. For documents that have mixed characteristics, we selected the predominant characteristic for their classifications.

Table 3

Chemical Warfare Document Types and Their Definitions

Type	Definition
Historical	Provides a historical account of the subject.
Opinion	Presents the beliefs of individuals who have special knowledge about the subject and only one side of an argument.
Issue review	Raises major points of controversy but does not attempt to resolve the controversy and supports no one argument.
Issue analysis	Raises major points of controversy and seeks to resolve the controversy.
Policy study	Evaluates alternatives systematically according to stated criteria and, in some cases, identifies a preferred alternative.
Simulation	Reports on the examination of a problem not by direct experimentation but by structured, frequently computer-based, gaming techniques.
Documentary	Presents expository "eye witness" material, often secondhand.
Test and evaluation	Collects and examines expository material critically by means of various structured procedures such as content analyses, case studies, surveys, field experiments, and intelligence procedures.

Judging the information quality

Next, we made judgments about the quality of the reasoning in each document and the purported facts pertaining to chemical warfare issues. Because so much of the information on chemical warfare is not empirical and, therefore, not subject to the usual questions about the soundness of methodology, we developed an exploratory set of criteria for our assessment of the quality of information. We list these criteria in table 4. Their applicability differs from source to source, and we made no attempt to use each criterion in every case. We made no effort to "score" the information sources on their quality or to verify the consistency of different reviewers in meeting our criteria. In short, we used the criteria as guides to assessing information rather than rigorously rating its quality.

Synthesizing the information

Our last step was to identify and integrate the best sources of information for addressing each question, to determine the overall degree of confidence in the answer to the question, and to identify remaining gaps and inadequacies. All else being equal, we judged test and evaluation information to be superior to other types of information. If we had "good" test and evaluation information, we relied on it and did not necessarily use sources of other types, except in briefly presenting the pertinent arguments. For questions for which we did not

Table 4

Document Assessment Criteria and Their Definitions

Criterion	Definition
Bias	To what extent is the author or source potentially involved in chemical warfare outcomes? Is the source a lobby organization for the military? All else being equal, an independent, uninvolved source is more credible than a potentially biased one.
Values	To what extent does the author make value judgments? How closely do values underlie the argument? To what extent do values rather than logic constitute the argument? The more the document substitutes values for logic, the less credible it is.
Assumptions	Are the assumptions explicit or implicit? Are they reasonable or unreasonable? What support is there for them? A document based on unstated, "shaky," or false assumptions loses credibility.
Logic	To what extent is the logic flawed? The tighter the logic, the more credible the document.
Facts	To what extent are facts the basis for the arguments? To what extent are the sources for the facts cited? A document that is based on facts that have been or can be verified is more credible than one that is not.
Competing alternatives	Does the argument account for competing strategies, hypotheses, or courses of action? Is a case made for rejecting alternatives? An argument for which competing alternatives have been analyzed has more credibility than one for which they have not.
Political and operational feasibility	To what extent does the argument take into account the political and operational feasibility of what is being recommended? Could the recommended course of action be implemented?

have test and evaluation information, we judged simulation information to be superior to other types, all else being equal. We followed the same procedure in relying on policy studies. We made no similar distinctions for relying on the other information types. If we had information consisting of only arguments, we used our assessment criteria to identify any weaknesses in them.

Organizing the report

The sequence of chapters in this report follows the order of our questions. In chapter 2, we discuss how the use of chemical weapons can be deterred and how the United States has chosen to pursue a policy of deterrence. In chapter 3, we compare U.S. Soviet offensive and defensive chemical warfare capabilities. In chapter 4, we examine the options for modernizing the U.S. chemical warfare system. In chapter 5, we report on our investigation of how modernization affects disarmament prospects. In chapter 6, we present our findings, identify questions that remain, and respond to agency comments on a draft of this report.

CHAPTER 2

HOW IS CHEMICAL WARFARE DETERRED?

A central issue in the chemical warfare debate is how chemical warfare can best be deterred. In this chapter, we attempt to answer three questions on chemical warfare deterrence: (1) What is a credible deterrence capability? (2) What are the different ways of deterring chemical warfare? (3) How has the United States chosen to pursue deterrence? Our review reveals a basic acceptance of the broad premise that having a deterrent to chemical warfare means having an actual and a perceived means and the will to inflict unacceptable consequences on a potential adversary. There are important differences, however, in the emphasis that different policy options, and different countries, place on any given means. While the evidence is not strong, historical analyses suggest that both the ability to defend against an enemy's use of chemical weapons and the ability to launch a retaliatory attack on that enemy (although not necessarily with chemicals) are important components of deterrence.

WHAT IS A CREDIBLE DETERRENCE CAPABILITY?

What are the essential elements of chemical warfare deterrence? A clear understanding of it is necessary for considering national policies, diplomatic postures, and military options for

QUESTION	SUBQUESTION
1.0 How is chemical warfare deterred?	1.1 What is a credible deterrence capability? 1.2 What are the different ways of deterring chemical warfare? 1.3 How has the United States chosen to pursue deterrence?
2.0 How do the United States and the Soviet Union compare in chemical warfare capability?	2.1 What are the U.S. and Soviet doctrines governing the use of chemical weapons? 2.2 How does the U.S. chemical stockpile compare with the Soviet Union's and how is stockpile need determined? 2.3 How do the U.S. and Soviet chemical warfare delivery systems compare? 2.4 How do the United States and the Soviet Union compare in defensive equipment and personnel? 2.5 How and to what extent have the United States and the Soviet Union prepared for implementation?
3.0 How can the United States modernize its chemical warfare system?	3.1 What factors are necessary for modernization? 3.2 What are the alternatives to binaries? 3.3 Do binaries have substantial advantages over unitaries?
4.0 How does modernization affect the prospects for disarmament?	4.1 How successful have chemical warfare disarmament efforts been? 4.2 What are the verification problems in banning chemical weapons? 4.3 What implications does modernization have for disarmament?

doctrinal and tactical development, but few sources have examined it in depth. The sources agree in accepting the basic premise that having a deterrent to chemical warfare means having an actual and a perceived means and the will to inflict unacceptable consequences on a potential adversary. Several authors define the elements of capability, or the means, that are specific to chemical warfare deterrence. Although their perspectives differ, common elements of capability can be identified. Elements of will are less tangible and are not specifically delineated either in the literature or in our report.

Knowledge review

We found wide acceptance of a broad definition of deterrence, but the definition applies to warfare in general, not specifically to chemical warfare. For example, the definition as stated by Kissinger (1962) posits that the objective of deterrence is to prevent a given course of action by making it seem less attractive than all possible alternatives. Deterrence is the product of power, the will to use it, and the adversary's assessment of these. The state of mind of the adversary is intangible in the equation.

Kissinger's expression of the definition leaves the issue of power unconstrained. That is, power, as a means or a capability, can be defensive or offensive or both and still be consistent with the definition. For example, offensive action as retaliation-in-kind or as escalation might be perceived by an adversary as unacceptable, but so might a strong defense, inasmuch as it might unacceptably waste the adversary's resources. Kissinger's definition also does not restrict offensive capability--it could be conventional, nuclear, chemical, biological, or a combination of these.

Definitions specific to the deterrence of chemical warfare tend to define capability more narrowly. They are based on beliefs about what capability must involve. Lennon (Meselson, 1978), for example, suggests that the following factors are pivotal in chemical warfare deterrence: the interests of the belligerents in limiting the damages and other consequences of war; the elimination or reduction of any advantage an enemy gains by initiating chemical warfare; a retaliatory capability that is credible across a range of conflict situations, does not encourage an enemy's pre-emptive attack, is not escalatory, and does not affect the nuclear threshold; and an unambiguously enunciated retaliatory response. These factors alter the general definition in a way that reveals Lennon's opinions. The factors of retaliation, for example, reflect his belief that a retaliatory capability is necessary to deter chemical warfare. But retaliation without escalation argues that a nuclear retaliation after a chemical attack is not credible--in other words, that the Soviets do not perceive NATO as willing to retaliate with nuclear weapons (and, thus, risk nuclear destruction). Hence, in Lennon's view, NATO's nuclear capability,

unaccompanied (as it is) by a perceived willingness to use it, cannot deter a chemical attack, regardless of the degree of that nuclear capability. This view is commonly held, with minor variations, by Baird (1974), Calvert (1974), Hart (1960), Hoeber (1981), Verna (1977), and others.

In contrast, some argue that the threat of nuclear retaliation to a chemical attack is in fact a deterrent. Finan (1974) and Nerlich (1981) see the escalatory threat of punishment, with the resulting possibility of nuclear exchange, as credible. A study by the Strategic Studies Institute (1981b) goes further, stating that a mutual assurance of destruction, arising from accepting the risk that a tactical nuclear response to a chemical attack might in turn escalate to a strategic response, is not only credible but also insures deterrence. To put this in Kissinger's terms, power for some may well be a nuclear capability.

According to all these definitions of deterrence, a perceived and an actual chemical or nuclear capability (that is, power) and the will to use it are critical. The elements of will are not explicitly delineated in the literature, although several authors give detailed views of the necessary components of capability. Dashiell (1981), for example, lists four requisites of a chemical capability. First is protection sufficient to enable defensive forces both to withstand the use of chemicals against them and to continue their military operations. Second is a credible retaliatory capability, which Dashiell believes must be able to retard the attacker's mobility, communications, and military operations to the same extent as the defender's. Third is a military doctrine that encompasses chemical operations: Dashiell explains the importance of having everyone on the battlefield know precisely what to do if a conflict escalates to chemical warfare or tactical nuclear warfare or both. Fourth is adequate training.

Robinson (1980) refines this further, including in the essential elements a stockpile of chemical munitions that has production and logistics support, research and development in production and logistics, production and logistics support for defense against chemical warfare, research and development in defensive gear, ample protective gear, and training in the use of and defense against chemicals. Hoeber (1980) does not separate offensive and defensive capabilities and reduces the list of essential elements to a munitions stockpile, testing facilities, and equipment, personnel, force structure, and training activities.

While all these elements of capability seem basically consistent and reasonable, we looked for evidence of their importance. In two relevant historical analyses--one by Brown (1968) and another by SIPRI (1971-75)--we found some support for the more broadly defined elements of adequate protection, credible retaliatory capability, doctrine, and assimilation. Brown

analyzed the inhibitors and stimulants of chemical warfare before and during World War II and concluded that public opinion and legal decisions were ineffective as restraints but that the military's failure to integrate or assimilate chemical weapons was an even more powerful inhibitor than fear of retaliation. Taking a slightly different approach, SIPRI began by examining instances from 1914 to 1970 in which chemical weapons have been used or allegedly used. Noting the restrained use of chemicals in World War II, SIPRI pointed, like Brown, to the lack of interest in chemical warfare among opposing military staffs. SIPRI identified the reason for the lack of interest as an incompatibility of chemical warfare with the fast-moving campaigns of World War II but also indicated that the rise of nerve agents after World War II has made chemical warfare more suitable for fast-moving military operations. However, SIPRI concluded from its analyses that chemical weapons are likely to be militarily attractive only in greatly asymmetrical conflicts. SIPRI found that when chemical weapons have been used "on a substantial scale," it has always been against an enemy known to be deficient in both defensive capability against chemicals and retaliatory capability of all types. SIPRI's argument must be tempered with the note that its sample of chemical warfare incidents was small.

Observations

The evidence is not strong but does suggest that both an ability to defend against chemicals and some type of substantial retaliatory capability (chemical, nuclear, conventional) are important components of chemical warfare deterrence. The ability to deter includes doctrine, stockpile, delivery systems, personnel and defensive equipment (such as decontamination and detection equipment, protective clothing, and force structure), and implementation (training, production facilities, and the like). These elements apply in theory equally to nuclear, conventional, and chemical retaliatory capabilities, although the literature tends to view them only as elements of chemical retaliatory capability, not as means to deterrence. As we have shown, the credibility of a nuclear versus a chemical retaliatory capability as a deterrent to chemical warfare is considerably controversial. Conventional capability is generally discussed only in combination with chemical or nuclear retaliation. Most people taking a position in the debate are proponents of maintaining a substantial chemical retaliatory capability.

WHAT ARE THE DIFFERENT WAYS OF DETERRING CHEMICAL WARFARE?

Nations seeking to deter chemical warfare could adopt a number of policy options. The options all involve the elements of power or capability as we detailed them in the previous section but differ in emphasis. At one extreme is chemical parity

with the Soviet Union, which presumably requires a highly developed retaliatory capability. At the other extreme is an international ban on chemical weapons, which presumably requires no retaliatory capability. Different nations have emphasized different options and, thus, different elements of capability.

Knowledge review

Relatively few sources discuss alternative ways of deterring chemical warfare. Rejecting nuclear retaliation as lacking credibility, most assume that the only alternative is the threat of the retaliatory use of chemicals. Two analysts, however, provide a comprehensive review of policy options--the Stanford Research Institute (SRI) in a policy study (Carpenter et al., 1977) and Robinson in an analytical article (1978).

The policy alternatives SRI examined are as follows: a diplomatic initiative toward a treaty on chemical warfare, a conventional warfare response, declaratory nuclear retaliation to chemical attack, an emphasis on defense (with a limited chemical retaliatory capability), and parity in chemical weapons with the Soviets. SRI assessed the assumptions and objectives of each alternative systematically and well, but the alternatives seem to suffer from overlap. Robinson (1978) appears to resolve this problem by collapsing SRI's five options into three: arms control; emphasis on weapons, which subsumes a conventional response, a nuclear response, and chemical parity; and chemical protection, which subsumes the emphasis on defense. We investigated the elements of capability in Robinson's framework, looking for instances of nations having emphasized any of the different alternatives.

Arms control emphasis

According to SRI, the objective of negotiating a chemical warfare treaty is to place an effective and verifiable ban on lethal and incapacitating chemical agents. Robinson does not believe that 100 percent verification is possible and, therefore, appears to be more willing than SRI to accept a partial ban as an objective. Robinson and SRI agree, however, that a nation that chooses to reduce the threat of chemical warfare by means of arms control treaties must nevertheless maintain some protection against chemicals. This might entail the elements of protective equipment, personnel, and training. Such protective capability is regarded as insurance against a treaty's violation.

Has any nation emphasized arms control as its chemical warfare policy? The SRI study indicates that many Europeans favor this option. Several major sources (DSB, 1981; Hoeber, 1981; and others) argue that the United States has adopted this policy, even carrying it to the extreme of unilaterally disarming without maintaining a strong defense.

Weapons emphasis

Policies that emphasize retaliation as the best way to deter chemical warfare can stress conventional, nuclear, or chemical weapons or combinations of them. In any case, the emphasis is clearly on a substantial ability to retaliate. SRI discounts the effectiveness of retaliation with conventional weapons on the ground that the nation that initiates chemical warfare degrades the opponent's performance without incurring similar difficulties, thus diminishing the retaliatory capability as a deterrent. Additionally, there is considerable controversy over whether a nation's declaring that it will retaliate with nuclear arms promotes deterrence. Several European military analysts believe nonetheless that the threat of retaliating to a chemical attack with a tactical nuclear response is more credible than the threat of retaliating in kind.

SRI sees the chemical retaliatory option as very costly in two areas. It notes that a credible retaliatory chemical warfare capability is expensive since a great many material and operational factors are involved, even when parity with the presumed chemical capabilities of other countries is not sought. SRI also indicates that this option is not popular in Europe, the probable battleground of a chemical war, and is, therefore, cause for dissension within the Allied command. While retaliation-in-kind is part of NATO's official policy, many writers (Hoeber, 1981, and Robinson, 1978, among them) question whether NATO has a credible retaliatory chemical warfare capability.

Defense emphasis

(U)In the SRI study, a chemical warfare policy based on defense includes the ability to retaliate with chemicals just enough to convince an enemy that no advantage would be gained by initiating a chemical attack. SRI assigns a moderate-to-high deterrent value to this policy. Both Robinson and SRI note that as an opponent's defense improves, the effectiveness of an ability to retaliate with chemicals against it declines. Robinson states that a good defense may compensate for a deficiency in chemical weapons but that having more weapons does not compensate for a poor defense. Robinson points out that a number of Western European countries, such as Sweden, have or are achieving sophisticated defense capabilities against chemical warfare (and seem content with this policy even without having chemical retaliatory capabilities). Robinson discusses a defense-oriented posture without reference to any policy of chemical retaliation.

Observations

We found no empirical base from which to argue for one option over another. SRI, in stressing that even a policy that emphasizes defense has to be accompanied by a limited chemical

retaliatory capability, expresses the belief that at least one country has a significant chemical offensive capability. Robinson, on the contrary, seems to believe that current chemical offensive capabilities are marginal at best, and therefore he favors a defense-emphasis policy without reference to chemical retaliation. This disparateness of orientations toward the likely value of the deterrence options may derive from the facts that SRI's study was sponsored by DOD and that Robinson has clearly become an advocate of chemical arms control. The important points, however, are that there seem to be different ways of achieving deterrence and that nations have selected different options and are emphasizing different elements of capability.

HOW HAS THE UNITED STATES CHOSEN TO PURSUE DETERRENCE?

The posture for chemical warfare deterrence that the United States adopts has profound military and diplomatic consequences for not only the United States but also Europe. In most chemical warfare scenarios, conflict occurs on a European battleground, where those most likely to suffer if deterrence fails are NATO's troops and European civilians.

Knowledge review

Many sources we reviewed give concise and consistent accounts of U.S. chemical warfare policy (Carpenter et al., 1977; DOD, 1982; Meselson, 1978). DOD's 1982 report to the Congress on chemical warfare includes the observation that the ultimate U.S. goal is a complete and verifiable ban on developing, producing, and stockpiling chemical weapons. DOD states in the report that, until weapons have been satisfactorily banned, the United States will maintain a chemical warfare capability sufficient to deter the use of chemical weapons against the United States and its allies and will refrain from being the first to use chemical weapons. Dashiell (1981) gives a more detailed breakdown of U.S. policy, which he sees as declaring "no first use" of chemical weapons, continuing to seek a ban on producing and stockpiling chemical weapons, maintaining the ability to deter the use of chemical weapons, and insuring the ability to adequately protect and defend against chemical attack.

Where does this general U.S. policy stand in relation to the policy options we outlined in the previous section? The SRI study (Carpenter et al., 1977) raises the point that the U.S. policy does not express clearly whether a retaliatory chemical capability is necessary for removing a first-use advantage (which would indicate the need for a relatively small stockpile and an emphasis on defense) or for fighting a war in defense of U.S. and NATO forces (which would require a relatively large stockpile and an emphasis on weapons). In brief, there is some question as to whether the U.S. policy should be characterized as emphasizing defense with limited chemical retaliatory capability or as emphasizing weapons with substantial chemical

retaliatory capability. Hoeber (1981) raises the question as to whether U.S. policy should be characterized as emphasizing arms control, since, in her view, the United States had been pursuing a policy of unilateral disarmament.

Observations

Whether U.S. policy emphasizes defense with limited chemical retaliatory capability or weapons or arms control, it is still predicated on retaliation-in-kind (in the absence of a total ban) as a deterrent to chemical warfare. The question of what chemical retaliatory capability the United States currently has or needs for deterrence is complicated by the fact that chemical warfare capability consists of many elements: actual and perceived doctrine, stockpile size and composition, defense equipment (for decontamination and detection and for individual and collective protection), personnel (that is, armed forces structure), and implementation (including training and production facilities). According to the sources we reviewed, these elements must be addressed in a coordinated manner if, given U.S. policy, chemical deterrence is to be credible. Additionally, unless the U.S. chemical warfare capability is perceived as high, U.S. willingness to retaliate with chemicals will be viewed as low. In the next chapter, we examine the actual and perceived U.S. and Soviet chemical warfare capabilities in order to determine whether either can satisfy the power side of the deterrence equation.

CHAPTER 3

HOW DO THE UNITED STATES AND THE SOVIET UNION COMPARE IN CHEMICAL WARFARE CAPABILITY?

Given a chemical warfare policy based on either first use or retaliation-in-kind, deterrence requires a perceived and an actual chemical warfare capability and the will to use it. While it is usually difficult to gauge a nation's willingness to use chemical weapons, it is certain that a credible capability is a condition for the belief that a nation will be willing to use them. In this chapter, we report on how the United States and the Soviet Union compare on each of the following capability factors: doctrine, stockpile, delivery systems, defensive equipment (for decontamination, detection, and individual and collective protection), the number and adequacy of defense personnel, and implementation (training, production facilities, and deployment). The number of sources discussing them is large and their quality is variable. Many of the literature sources, for example, are brief issue reviews or analyses that give no detailed information. Some give no references to the source of their material.

The sources we studied agree in accepting the notion that the Soviets possess a formidable offensive capability, even though little is known about the specifics of that capability. In trying to determine what is known about the Soviet military

QUESTION	SUBQUESTION
1.0 How is chemical warfare deterred?	1.1 What is a credible deterrence capability? 1.2 What are the different ways of deterring chemical warfare? 1.3 How has the United States chosen to pursue deterrence?
2.0 How do the United States and the Soviet Union compare in chemical warfare capability?	2.1 What are the U.S. and Soviet doctrines governing the use of chemical weapons? 2.2 How does the U.S. chemical stockpile compare with the Soviet Union's and how is stockpile need determined? 2.3 How do the U.S. and Soviet chemical warfare delivery systems compare? 2.4 How do the United States and the Soviet Union compare in defensive equipment and personnel? 2.5 How and to what extent have the United States and the Soviet Union prepared for implementation?
3.0 How can the United States modernize its chemical warfare system?	3.1 What factors are necessary for modernization? 3.2 What are the alternatives to binaries? 3.3 Do binaries have substantial advantages over unitaries?
4.0 How does modernization affect the prospects for disarmament?	4.1 How successful have chemical warfare disarmament efforts been? 4.2 What are the verification problems in banning chemical weapons? 4.3 What implications does modernization have for disarmament?

threat, it is important to consider whatever intelligence information is relevant. In convening the Defense Science Board in 1980, DOD specifically asked it to review intelligence data on chemical warfare, and DSB's 1981 report accordingly presents its intelligence findings and describes how they were derived. We believe that the report is generally very credible. Its observations and conclusions on intelligence have not been challenged, and in fact DOD used them extensively in its 1982 report to the Congress on chemical warfare. Furthermore, DSB's findings are consistent with our own as we reported them in 1977 (GAO, 1977a,b). As for our earlier review, for this one too we have not verified the intelligence data that we examined. We have referred to it in this report, however, because DOD and DSB reports are important in all discussions of chemical warfare issues.

The assessments that have been made of the U.S. retaliatory capability differ, and the differences raise significant questions about the specific details of its capability. More is known about the Soviet Union's defensive ability than its offensive ability; therefore, the comparisons of the two nations that can be made with the greatest confidence have to do with defense. The most favorable comparison for the United States is in individual protection. Comparisons on other defensive factors are less favorable, with the Soviets appearing to have built a strong defensive capability for nuclear, biological, and chemical warfare that the United States has not matched. There are many questions, however, that stem from gaps and inconsistencies in the information.

WHAT ARE THE U.S. AND SOVIET DOCTRINES GOVERNING THE USE OF CHEMICAL WEAPONS?

How a nation's military doctrine sets forth chemical warfare operations is critical to its chemical warfare capability. Unless the doctrine has been developed so that everyone on the battlefield from commander to foot soldier knows, with respect to chemical warfare, precisely what procedures to follow and when, how, and why, the country's ability to wage or defend against chemical warfare will be low. In this section, we compare and contrast what we know about the U.S. and Soviet chemical warfare doctrines and identify the questions that remain.

The sources of information we examined indicate that the Soviet doctrine for chemical warfare is well developed, and they depict the U.S. doctrine as poorly developed and not openly available. We found, however, that there is some question about whether the Soviet doctrine deserves the "high marks" that some have given it. That is, the Soviet Union's perceived capability may be much greater than it actually is. The evidence does support the belief that U.S. doctrine--that is, its joint doctrine, its doctrine for integrated battlefields (those in which conventional, nuclear, chemical, and biological munitions may

all be used), and its doctrine for the individual services--is inadequately developed, but here, too, there are unanswered questions about what specific doctrine the United States should develop.

What is the Soviet doctrine on chemical warfare?

Both the classified and the unclassified sources generally agree in their high assessment of how well the Soviets have developed their warfare doctrine. However, the evidence that would support the accuracy of this assessment is not clear.

Knowledge review

We have been told, as we have reported (GAO, 1977a, 1981), that Soviet chemical doctrine supports massive, surprise strikes against a broad spectrum of targets from the forward edge of the battle area to rear areas more than 100 miles behind the lines. The targets include major troop concentrations, nuclear launch sites, air defense systems, command and control facilities, airfields, and rear area supply and logistics facilities. In addition, Carpenter et al. (1977), Dick (1981), Erickson (1979), Finan (1974), Hoeber and Douglass (1978), and Robinson (1978) all suggest that the Soviets would use chemical weapons to achieve one or more of the following specific objectives:

--to contaminate reinforcement ports and airfields (thus limiting air sorties and the advancement of new forces); supply depots, supply lines, and equipment; nuclear delivery centers, headquarters commands, and communications centers;

--to cause heavy casualties in sectors selected for breakthrough assault in a concentrated surprise attack on forward positions;

--to harass rear areas with delayed action fuses set to go off at night, when surprise is likely;

--to prepare drop zones for surprise airborne assault or the establishment of bridge heads;

--to interdict key battlefield points (road junctions, choke points, bridges over major rivers, railway points) with nonpersistent agents that would leave these facilities intact for later Soviet use;

--to destroy pockets of particularly effective resistance, especially antitank defenses;

--to deny favorable ground to the enemy (good ground for launching a counterattack, for example).

The sources consistently express the view that nonpersistent agents are the most likely to be used for producing casualties and that persistent agents are the most likely to be used for denying ground, mobility, or facilities to enemy forces in combat.

The sources agree that Soviet doctrine makes chemical weapons part of an overall warfare strategy that also calls for the use of conventional and nuclear weapons (at least, tactical nuclear weapons). It is not generally believed, however, that the Soviet doctrine includes the employment of chemical weapons against the continental United States (Finan, 1974; GAO, 1977b). Instead, it is believed that the Soviets would attack the poorly equipped armies of Afghanistan
and armies on a battlefield in Western Europe. Most scenarios depict the use of chemical weapons in Europe as involving a conflict between the armed forces of the United States and NATO and the armed forces of the Soviet Union and the countries of the Warsaw Pact.

What are these assessments based on? The majority of our sources, classified and open, do not indicate how they arrived at their conclusions about Soviet doctrine. The 1981 classified Defense Science Board report suggests, however, that its comments are based on a composite of intelligence information on Soviet chemical warfare capability, including intelligence information
. A review of Hoeber's 1981 book on Soviet chemical warfare policy suggests that she also deduced her assessment from translations from the Soviet press, open knowledge of Soviet chemical munitions and delivery vehicles, and logical reasoning about what it is likely that the Soviet Union would find it in its best interest to do.

Observations

While the bases for composite pictures of Soviet doctrine are not generally clear, the pictures themselves argue strongly that the Soviet offensive chemical warfare doctrine is well developed. Nevertheless, there is some question as to whether this perception of Soviet chemical warfare doctrine is founded on knowledge or on assumptions.

What is the U.S. doctrine on chemical warfare?

We found general agreement that the U.S. doctrine on chemical warfare has not been adequately developed but little specific detail about what is required. The problems that have been identified are that there is no joint doctrine, no doctrine adequately covers integrated battlefields, and doctrine for the individual services is poorly developed.

Knowledge review

An investigation of U.S. chemical warfare doctrine quickly turns to the question of whether or not there is a U.S. doctrine on chemical warfare. Hoeber (1981) states that the United States has no tactical doctrine for employing chemical weapons on the battlefield. The 1981 DSB report indicates that plans and procedures for employing chemical munitions have atrophied and that, inasmuch as each service has had responsibility for developing its own doctrine, there is no joint doctrine. In other words, no document spells out how the services are to coordinate in defending themselves or in employing chemical agents to accomplish precise military objectives, how they are to use equipment, and how they are to sustain a military attack in a chemical environment. DSB recommended in its report that a focal point be established in DOD for chemical warfare matters and that DOD clarify doctrine and other aspects of its chemical program. In August 1981, DOD did establish a focal point for chemical warfare matters, but we still find no evidence that an integrated and comprehensive U.S. chemical warfare offensive and defensive doctrine has been formulated.

We also find no source that raises questions about the place of a joint chemical warfare doctrine within a larger strategy for tactical war. Recent planning efforts by the Army (Army 86 and Airland Battle 2000 documents) acknowledge the need to assess the demands that modern battlefields, particularly integrated battlefields, make on tactics, troops, and material. However, no document that we reviewed addresses the specific doctrinal requirements that the concept of an integrated battlefield would seem to imply for chemical warfare.

We looked for sources that examine the chemical warfare doctrines of the individual services. DOD admitted in its 1982 report to the Congress that chemical warfare doctrine was neglected by the services during the 1970's but asserted in the report that all services were now improving and developing operational concepts in chemical warfare. Only Monohan (1980) specifically criticizes a service's chemical warfare doctrine: he found Marine Corps chemical warfare doctrine to be inadequate in that policy guidance has not been promulgated effectively, the doctrine does not elaborate on the accomplishments of unit missions, and the doctrine does not emphasize aviation units, especially aircrews. Monohan's illustrations of these problems leave open questions about what would happen to an amphibious task force, for example, subjected to chemical attack after it had begun an initial assault. Other questions include what decisions would be necessary other than those needed for performing survival tasks, how the momentum of assault would be maintained while survival tasks were being performed, and what casualty level would determine the order to end the assault. Because of the lack of doctrine on mission accomplishments, these questions cannot be answered. For the services over all,

we found that specific criticism of this kind, pinpointing where doctrine should be developed, is lacking. That the doctrine is in fact underdeveloped, however, is unquestionable.

We did find that U.S. doctrine exists in a very general way. Because our earlier work indicated that the Army's chemical warfare plans are the most highly developed among the services, we examined the Army's field manual on chemical warfare use. We also looked at DOD's 1982 report to the Congress for current doctrinal concepts.

Army Field Manual FM 3-10: Employment of Chemical Agents (1971) states that it provides doctrinal guidance for the employment of antipersonnel chemical agents. It states that chemical munitions may be employed separately or with other munitions in military operations and that chemicals are used to cause casualties among enemy troops, reduce the enemy's effectiveness by harassment, or restrict the enemy's use of terrain or material. More particularly, they are used to

--produce casualties in an area selected for penetration and assist attacking units in an initial breakthrough;

--slow the enemy's advancement by forcing it to wear gas masks for protection against persistent agent attacks while it is concentrating for attack;

--attack positions while physically preserving industrial complexes, cultural institutions, lines of communication, and other facilities and material;

--exploit confusion and lack of discipline at the fringe of a nuclear strike;

--avoid physical obstacles to maneuvering that have been created by nuclear and high-explosive munitions;

--contaminate alternative defense positions in an attempt to fix the enemy in an uncontaminated area in which it can be attacked with other weapons;

--protect troop flanks and support forces along the forward edge of battle.

Thus, according to the manual, chemical weapons are intended for application as part of both nuclear and nonnuclear warfare.

The Army field manual also lists some considerations for deciding whether to use chemical weapons. They include the influence of weather and terrain on chemical agents, the time that is acceptable for producing casualties, and the presence of civilian populations in the target area. However, the manual does not provide specific guidance to the Army user. For example, the manual does not indicate what effects the presence

of civilian populations of a certain size or within a certain distance of the target should have on the use of chemical weapons.

The 1982 DOD report to the Congress indicates that chemical weapons should be used to attack enemy units front and rear. The two goals, as stated, are to produce casualties and to hinder the enemy's performance. The report further identifies other goals or effects to strive for, targets for chemical weapons, and specific weapons to use.

Observations

We found that many sources decry the lack of U.S. doctrine on chemical warfare but very few give details of what is needed. The main question is what specific doctrine should be developed if U.S. forces are to know how to defend, operate, and attack in a chemical environment.

Summary and conclusions

Our findings indicate that the Soviet doctrine for chemical warfare is well developed and clearly articulated and that the U.S. doctrine is poorly developed and inadequate. While questions remain as to whether the evidence supports the "high marks" that have been given to Soviet doctrine, the evidence does support the perception that U.S. doctrine--joint doctrine, doctrine for integrated battlefields, and doctrine for the individual services--is inadequate. The specific efforts required to make U.S. chemical warfare doctrine adequate have not been identified. Some questions that should be addressed are

--Is it possible, according to U.S. doctrine, to deny area to attacking forces if they have initiated a chemical attack and are wearing protective gear or are protected inside personnel carriers?

--How will NATO's concern about the lethal impact of chemical weapons on civilians be incorporated into the U.S. doctrine? How will incorporating this concern limit the part of the doctrine whose goal is to produce casualties among frontline enemy troops?

--What defense doctrine is implied for the United States given its policy of not being the first to use chemicals?

--Should the U.S. doctrine specify how chemical weapons are to be used in combination with other weapons?

--If chemical retaliation is possible only where U.S. forces are present, should the U.S. doctrine pinpoint the limits of the sectors in which an attack can be launched?

HOW DOES THE U.S. CHEMICAL STOCKPILE COMPARE WITH THE SOVIET UNION'S AND HOW IS STOCKPILE NEED DETERMINED?

The ability to pose a serious chemical warfare threat, whether offensive or retaliatory, rests, of course, on the possession of chemical munitions. That is, the size and composition of a chemical stockpile determines what targets can be struck, what tactics can be used, and an attack's intensity. From the sources we reviewed in the classified and unclassified literature, we have concluded that despite many claims that the Soviets maintain a chemical arsenal dwarfing that of the United States, variations in the estimates of the size or the composition of the Soviet stockpile indicate a lack of accurate information regarding specifics. Moreover, analysis of the literature reveals uncertainty about the quantity, form, and condition of lethal chemicals in the U.S. stockpile. We are also left with many questions about the criteria that are used to determine how large the U.S. stockpile should be.

What are the size and extent of the Soviet stockpile?

Classified and unclassified sources alike agree that little is known about the size or the composition of the Soviet stockpile.

Knowledge review

Several open sources attest to the absence of a sound basis for estimating the size of the Soviet stockpile. Robinson (1980) notes that not since 1938 has a Soviet official openly spoken or written about an offensive chemical warfare capability. Ember (1980), Robinson (1980), and Robinson and Meselson (1980) observe that the open literature adds no knowledge about a Soviet stockpile. Where, then, do the many estimates in the open literature come from?

The Association of the U.S. Army (1980), the Center for Defense Information (1980), and Robinson (1978, 1980) suggest that the estimates arise from examining either presumed Soviet doctrine or presumed Soviet capabilities. Ember (1980) states that the average estimate of the Soviet stockpile seems to be 350,000 agent tons; Robinson (1980) and Ruhle (1977) indicate that the ranges that are usually given are between 200,000 and 700,000 agent tons of chemical weapons. Robinson (1978) provides an example of how estimates vary by citing three

West German reports, two of which assert that the Soviet stockpile contains 350,000 tons while the third asserts 700,000 tons.

In our search for reliable estimates of the Soviet stockpile, we found that even classified documents leave doubt about the estimated size of the stockpile. In two 1977 reports (GAO, 1977a,b), we cited the Defense Intelligence Agency (DIA) and the Central Intelligence Agency as believing that the Soviet stockpile is adequate to meet Soviet operational requirements. DIA had indicated that the Soviets have a operational capability of tons. Two simulation studies recently conducted by the Institute for Defense Analyses (Kerlin, 1980, 1981) also fix Soviet delivery capability at agent tons per day, the rationale being that this is realistically what the Soviet forces could use in a day. DOD (1982) admits to a lack of knowledge about the Soviet stockpile but argues that even the lowest estimates give the Soviets substantial capability. The 1981 DSB study is very clear, however, that little is known about the stockpile and adds that

(p. 19). The DSB study reports that fewer than

Observations

With such diverse information on the Soviet stockpile, there are obviously some questions whose answers could affect U.S. and NATO preparations for chemical warfare. Does the Soviet doctrine imply the need for an offensive chemical stockpile? What evidence is there that Soviet demilitarization facilities can destroy defective or obsolete chemical munitions? Is there evidence that the Soviets have taken special precautions with various arsenals, munitions transportation, or testing ranges that might be associated with chemical weapons? Have any of the Soviets' training exercises used offensive chemical warfare tactics?

What are the size and extent of the U.S. stockpile and how is stockpile need determined?

Most of the sources we reviewed indicate that the United States has a total of about tons of chemical agent in bulk storage and about agent tons in munitions. The vast majority of this tonnage is reported to be contained within the continental United States. We found disparities in the estimates of the total amount of agent and the amount stored in the continental United States that appear to stem at least

partly from differences in defining the types and conditions of bulk agent and munitions that are counted. Our review leads us to doubt whether a valid assessment of U.S. retaliatory chemical warfare capability actually exists, although we have been told by DOD officials that a new assessment is under way.

Additionally, what is thought of as "necessary" in stockpile size appears to be based on perceptions and estimates from various field commanders concerning the use and effectiveness of chemical warfare in a European conflict. Our review also leads us to raise questions about the adequacy of the basis on which the stockpile requirement has been defined.

Knowledge review

Stockpile size and condition. In analyzing the composition and size of the U.S. chemical warfare stockpile worldwide, we drew heavily on classified reports. The 1982 DOD report, the 1981 DSB report, and reports by the Institute for Defense Analyses (Kerlin, 1980, 1981) all use DOD data. In earlier reports, we also reported DOD information on stockpile size. The numbers differ considerably, however, as can be seen in the summary of reported total agent tons in the U.S. chemical stockpile in table 5.

Why are the discrepancies so great? DOD maintains data on the amount of bulk agent and agent in munitions, on the amount of nerve agent and mustard agents, and on the condition of the agents and munitions (classifying them "serviceable," "unserviceable but repairable," and "obsolete and unrepairable"). DOD maintains these data for three stockpile locations--the continental United States, or CONUS, Europe, and the Pacific. We found that at least some of the disparity seems to arise from differences in how the types and conditions of bulk agent and munitions are counted. We made this judgment as follows.

First, we looked more closely at the stockpile by location, and we concluded that most of the discrepancy is found where most of the total stockpile is--in the continental United States. We display this finding in table 6. In looking further at the problem, we also found that the most frequent discrepancies are in the quantity of the stockpile in munitions rather than that in bulk. We display this point in table 5 and also indicate that the disparities seem centered in the condition of the munitions that are counted. (There is one widely discrepant number in the stockpile bulk column; however, given the relative consistency of the other bulk counts, we have treated it as an exception.)

Next, we examined the counts of nerve agent munitions, focusing on the U.S. continental stockpile. The 1981 DSB study states that the total U.S. continental stockpile of serviceable munitions (artillery shells, bombs, spray tanks, and land mines)

Table 5

Total Reported U.S. Chemical Stockpile, Stockpile Bulk, and Munitions in Agent Tons

Report	Stockpile	Stockpile bulk	Munitions
GAO, 1977(c)			
IDA, 1980			
DSB, 1981			
GAO, 1981			
IDA, 1981			
DOD, 1982			
JCS, 1982[g]			

[a]Serviceable
[b]Serviceable and repairable.
[c]Annex H, p. H-2.
[d]Annex I, p. I-3
[e]Includes munitions to be demilitarized.
[f]Serviceable and unserviceable.
[g]Unpublished memorandum, not in our bibliography.

contains about tons of lethal nerve agent. The 1981 IDA study presents the lower figure of agent tons. Regarding weapons that are currently not usable but are repairable, the 1980 IDA study (Kerlin, 1980) indicates that about agent tons are contained in such munitions, whereas the 1981 DSB study gives a figure of about agent tons. Thus, the disparities seem to reflect differences in defining what is usable and what is not usable but repairable.

Table 6

Total Reported U.S. Chemical Stockpile by Storage Location in Agent Tons

Report	CONUS	Europe	Pacific
IDA, 1980			
DSB, 1981			
IDA, 1981			
DOD, 1982			

[a]There are also approximately agent tons in unrepairable or obsolete munitions awaiting disposal.
[b]Refers to "ready or repairable" stocks, with a "small quantity" of bulk agent in the Pacific.

In 1977, we reported that better management of lethal chemical munitions and agents was needed (GAO, 1977). Among the problems we identified was that the true condition of the stockpile was unknown. Our findings indicated that its serviceability may have been greatly understated. We reported that many of the unserviceable classifications were a result of minor nonfunctional defects, such as container rust, which do not affect usability. We also found that inspection samples were neither random nor representative. We found entire production lots classified as unserviceable for only a few defects. We also found that little had been done to maintain the stockpile as serviceable or to restore its unserviceable portions.

In 1981, we investigated the status of DOD's implementation of our 1977 report recommendations (GAO, 1981). No new field work was conducted during that review. The picture was confused. We thought that DOD's explanation about whether samples were probabilistic or judgmental was still not clear. We were not able to determine how much and where re-warehousing was done, and although restoration had begun, much of the stockpile still needed to be restored. In brief, areas we cited in 1977 as needing improvement still need improvement. It appears that at the time of our 1981 report we did not have a valid assessment of the U.S. offensive chemical warfare capability, and we have found no new evidence for the present review that suggests that the situation has changed.

Stockpile composition. The sources we reviewed for this report indicate that the European stockpile is the of the U.S. chemical arsenals. It contains about agent tons, which according to figures supplied to DSB (1981) includes about

.

The Pacific stockpile is said by DSB to consist of about agent tons of

. Of this total

. The DSB report also indicates that

.

As for the stockpile in the continental United States, the sources we reviewed generally agree that a proportion of

the U.S. chemical stockpile is in bulk storage and a proportion is also mustard agent. DSB indicates that serviceable nerve agent munitions consist mostly of short-range artillery projectiles (about) filled with GB or VX. DSB reports that the approximately

of the continental chemical warfare stockpile.

In short, the sources we reviewed indicate that the United States has emphasized short-range GB nonpersistent artillery munitions over long-range chemical weapons. Additionally,

. Our review raises questions that have yet to be answered about whether a valid assessment of the total U.S. stockpile size, condition, and composition has been made.

Stockpile need. The 1982 DOD report to the Congress states that the worldwide U.S. stockpile should contain agent tons. In developing this figure for the stockpile requirement, the Joint Chiefs of Staff (JCS) used information from theater commanders-in-chief, information that was, according to the DOD report, based on a variety of factors, including weapons effects and the ability of the weapons to deliver chemical munitions. The commanders had based their assessment of their stockpile requirement on

The DOD report, citing the JCS statement that agent tons are needed for the U.S. chemical warfare stockpile, was based on these three criteria. DOD states in the report that while the total agent tonnage currently on hand exceeds this amount, usable tonnage currently on hand is much less. It is noted in the report that the current stockpile lacks a long-range delivery threat and presents logistical problems stemming from the elaborate safety precautions that are required in transporting chemical weapons.

Another study by IDA (Kerlin, 1981) on chemical warfare scenarios in Europe was also sponsored by the JCS, although it is not described in the DOD report to the Congress. The objective of the IDA study was to examine NATO's ability to respond to chemical attacks from the Warsaw Pact forces and to estimate what size and composition a chemical munitions stockpile should be to meet certain military objectives in central Europe in

. The study, which is based on a simulation, used a computer model (TACWAR) to portray a two-sided theater conflict. In the simulation, the current size and composition of various U.S. stockpiles of chemical munitions that could be made available by

We have made an extensive critique of the use of models for gauging the contributions of new weapons and tactical concepts (GAO, 1980). In that report, we concluded that quantitative models are beneficial only when they complement expert judgment and objective fact. The assumptions and data on which such models are based are usually open to challenge. Notwithstanding this qualification, the IDA simulation appears to be one of only very few studies that can be used in determining U.S. stockpile requirements.

The 1982 DOD report to the Congress does not indicate, however, that information from the 1981 IDA study played a role in the formulation of the figures representing U.S. requirements of size and composition for the chemical weapons stockpile. Thus, the relation between the JCS estimate of a worldwide stockpile need of agent tons and the IDA suggestion that

) is not clear. Do these figures, taken together, imply that between agent tons are required for the U.S. chemical weapons stockpile outside the ? How does the range of the IDA estimate compare with the estimate of the commanders-in-chief? What is the likelihood that the delivery systems and munitions analyzed in the IDA study (Kerlin, 1981) could be established in Europe in a timely manner? In brief, a number of questions remain unanswered about how the JCS estimated the U.S. worldwide stockpile requirements and how DOD used information from the JCS-sponsored study (Kerlin, 1981) on chemical warfare in Europe.

Observations

Our review in this area leaves us with many information gaps about the current stockpile size, composition, and condition and about estimates for current and future stockpile needs. Questions about the stockpile as it is now include the following:

--How often and with what sampling methods are the chemical stockpiles in Germany, the Pacific, and the continental United States checked for their stocks of serviceable and unserviceable but repairable chemical munitions? Are the

estimates of serviceable chemical munitions a random sample of munitions or the discretionary judgment of military personnel?

--Has the agent filler of the munitions been tested recently for purity and potency? When was the last time any such testing was done in Europe? In the United States? In the Pacific?

--What funds are being spent to maintain the chemical munitions and what maintenance activities are undertaken? Would increasing the inspection and maintenance activities substantially prolong the usable life of munitions in the U.S. stockpile?

--How many unserviceable but repairable munitions are there in Europe? In the United States? Have they been classified as unserviceable because they are leaking agent or agent filler and no longer pass Army purity standards? How many have been so classified because of problems with the shell or projectile casing or the storage containers? How much would it cost to have these chemical munitions repaired and maintained?

--Within the last year, how many and what type of chemical munitions have been classified as unserviceable in Europe? In the United States? For what reasons? Within the same year, how many and what type of chemical munitions were "reclaimed" from being unserviceable but repairable?

--What proportion of the chemical munitions stockpile in the continental United States is in bulk storage? What proportion of the munitions thus stored can be assessed directly for defects bearing on the serviceability of the munitions?

--How many of the currently serviceable chemical munitions will not be compatible with U.S. or NATO weapons in the next 5 years because they are being phased out of service? What ammunition design and performance criteria will these new weapon systems require that are not met by existing chemical munitions? Could effective modifications be made to new delivery systems or to existing chemical munitions that would permit the continuing use of existing chemical munitions?

As for stockpile needs, we have observed that the U.S. stockpile in Europe is of the three U.S. arsenals. If the 1981 IDA estimate of a need for between agent tons can be substantiated, the existence of approximately agent tons of serviceable munitions in Europe raises several questions:

--How would DOD choose to configure the European stockpile in terms of delivery systems and munitions? The current European stockpile contains

.

--Would producing casualties among Soviet ground forces and degrading air fields require a chemical warfare delivery system containing weapons other than air-delivered bombs? Exactly what configuration of munitions and delivery systems would be needed in central Europe to produce enemy casualties and degrade their targets as delineated in the 1982 DOD report to the Congress? The current stockpile in Europe contains

.

--Would persistent agent, which is suitable for both punishment and denial, be stressed in deployment, given that DOD and the commanders-in-chief stress degradation of target performance? Many of the chemical munitions currently in Europe are filled with .

--The difference between the JCS estimate of tons of agent needed for the U.S. worldwide stockpile and the estimate of agent tons cited by IDA leaves some doubt as to how much of the JCS worldwide estimate should be apportioned to Europe and, given NATO's reticence on chemical warfare, how it might or could be deployed for availability on a European front.

--IDA has linked target degradation and casualty production, but this raises the question of whether the amount of agent (measured in milligrams per square meter) that has to be delivered over the target area to force Soviet and Warsaw Pact forces into a protective posture (thus degrading their performance, as is consistent with DOD criteria for using chemical weapons) is really as great as the amount that is needed to create a percent casualty rate among unprotected forces (the level that IDA assumes is necessary to degrade their combat performance by forcing them into antichemical protective postures). Meselson (1980) and Robinson (1982) state that only a small percentage of artillery shells containing chemical agent need be fired to degrade an enemy. The data required for an answer seem not to exist.

--Whether chemical retaliatory strikes would be equally effective against infantry and artillery, for example, is open to question. A 1980 study by Miller suggests that U.S. chemical warfare attacks on Soviet artillery may have very little impact on their operations.

Summary

The available information tells little about the specifics of the Soviet stockpile and leaves open many questions about the size, composition, and condition of the U.S. stockpile. Classified sources attribute the

. As for the U.S. stockpile, we conclude that a valid assessment of the U.S. retaliatory capability seems not yet to have been made. Additionally, we question the extent to which and the manner in which simulation findings were used in deriving the DOD estimates of the U.S. worldwide chemical warfare stockpile requirements.

HOW DO THE U.S. AND SOVIET CHEMICAL WARFARE DELIVERY SYSTEMS COMPARE?

Delivery systems are critical components of any chemical warfare offensive or retaliatory capability. How military forces plan to deliver chemical agents reflects their doctrine and, thus, indicates the utility they perceive for chemical warfare, the targets they are likely to attack, and the priority they set for the objectives of physically destroying or hampering the enemy, denying the use of area, or achieving antipersonnel effects. Therefore, knowledge of the Soviet system for delivering lethal chemical agents allows an understanding of U.S. and NATO vulnerabilities and has implications for defensive doctrine, chemical detection and decontamination needs, and general mission accomplishments.

Our major finding is that, as with the Soviet stockpile, there is a perception of Soviet capability that seems not to be strongly supported by data. Thus,

, classified and unclassified literature alike generally regards the Soviet delivery capability as a substantial threat. There is widespread belief that the Soviets can deliver chemicals in warfare with all major tactical weapon systems--missiles, rockets and multiple rocket-launching systems, bombs, and aerial spray tanks. We also find general agreement that is supported by classified information that the United States, on the contrary, is limited by having an inadequate long-range delivery capability.

What is the Soviet delivery capability?

The sources we reviewed indicate

. The Soviets are nevertheless credited, in the classified and unclassified literature alike, with the ability to deliver massive amounts of chemical agent at targets throughout NATO territory.

Knowledge review

The Defense Science Board has pointed out that the U.S.

(DSB, 1981). Having made this assertion, however, DSB has gone on to state that "available evidence" suggests that the Soviets have missiles, rockets and multiple rocket launchers, artillery, bombs, aerial sprays, and land mines that contain lethal chemicals. DSB does not elaborate on "available evidence." The picture is mirrored in other classified works for which DOD is the major information source (Kerlin, 1980; GAO, 1977a,b; DOD, 1982).

Like the classified literature, the unclassified literature concludes that not only do the Soviets have a wide range of ways to deliver chemical warfare munitions but also this array gives them the ability to strike anywhere within NATO (Association of the U.S. Army, 1980; Crelling, 1978; Dick, 1981; Erickson, 1979; Finan, 1974; Hoeber, 1981; Hoeber and Douglass, 1978; Robinson, 1978, 1980). In table 7, we summarize the agent and delivery system types and the range of fire that have been attributed to the Soviets.

Open articles and reports indicate various sources for their assessments. As Robinson (1980) notes, at one time or

Table 7

The Maximum Range of Soviet Agent and Munition Systems in Miles[a]

Agent	Munition	Maximum range
Nerve		
Blister		
Blood		

[a]For bombs, the range of chemical bombs would vary with the aircraft used for delivery.

another, Western sources have referred to the existence of chemical munitions for almost all Soviet weapon systems that are in principle suited to chemical warfare. Our review indicates that these often-cited Western sources are U.S. and Western European military journals, U.S. DOD posture statements and annual reports, and Western European newspaper articles. In some cases, the reasoning seems to have been based on presumed knowledge of the Soviet chemical warfare inventory from World War II, lack of evidence that these weapons were ever destroyed, knowledge of current Soviet weapons delivery systems, and assumptions that the Soviets would have updated their capability. The extent of this guesswork can be seen in estimates that are given for the proportions of Soviet shells, warheads, and bombs containing lethal chemicals--they range from 10 to 50 percent.

Observations

We find an unanswered question about the capability of the Soviet chemical weapons delivery system. However, assuming that the high estimates of the Soviet ability to deliver chemical agents are correct, then the potential threat posed to NATO and the United States is serious and has implications for defensive doctrine, collective protection, decontamination, and the like. For example, given Soviet long-range capabilities, it is not clear whether U.S. and NATO rear command and control centers, airfields, depots, and supply centers could adequately defend against chemical attack. We are left with the overall question (which we take up in chapter 4) of the extent to which U.S. planning shows a coordinated and comprehensive defensive response to the potential Soviet threat.

What is the U.S. delivery capability?

According to the literature, the United States does not have, apart from some chemical-filled bombs, a long-range chemical weapons delivery system. Our review indicates that the weapon systems

Knowledge review

Our sources for information on U.S. delivery systems are the same as those we discussed in the section on the U.S. stockpile. By and large, these are classified sources that drew heavily from several of our own earlier reports. The open literature generally agrees that there is a serious deficiency in the U.S. ability to threaten Soviet and Warsaw Pact targets in rear echelons (see, for example, Robinson, 1978, 1980, 1982). The weapon systems that

U.S. long-range capability is represented by 500-lb and 750-lb

bombs

Additionally, according to both classified and unclassified sources, other short-range weapons in the U.S. inventory (115-mm rockets and 105-mm and 155-mm projectiles) are becoming obsolete and being phased out of the inventory. We noted in a previous report that warheads for several missiles were designed by the United States but never manufactured (GAO, 1977).

Observations

The United States relies heavily on short-range artillery systems for its chemical delivery capability. Given the short range of U.S. systems and the presumed excellence of Soviet defense, we are left with the question of how a U.S. chemical weapons retaliatory strike could significantly impede, degrade, or punish Soviet forces. In terms of U.S. long-range capability, the literature raises the question of whether, given Soviet anti-aircraft capability, air-delivered chemical-filled bombs are efficient enough to enable the United States to make a long-range chemical warfare strike.

Summary

If the descriptions of Soviet delivery systems are accurate, then the Soviets have a clear advantage over the United States in both the amount of chemical agent that can be delivered and the distance over which it can be delivered. This conclusion must be qualified,

. Assuming that the Soviets have an ability to strike at rear echelon U.S. and NATO reserves, supply posts, and depots with long-range systems, the following questions about U.S. offense and defense have not been answered:

--Given the short range of U.S. systems and the presumed excellence of Soviet chemical warfare defenses, how could a retaliatory strike significantly impede, degrade, or punish Soviet forces?

--Are U.S. rear command and control centers, airfields, depots, and supply centers adequately prepared for an enemy attack?

--Assuming some Soviet anti-aircraft capability, do air-delivered chemical-filled bombs give the United States an efficient long-range chemical strike capability?

HOW DO THE UNITED STATES AND THE SOVIET UNION COMPARE IN DEFENSIVE EQUIPMENT AND PERSONNEL?

Clearly, one way to limit the effectiveness of a potential aggressor's chemical weapons is to be adequately protected

against attack. Identifying the relative defensive abilities of U.S. and Soviet forces makes possible a partial assessment of their vulnerability to chemical attack. This assessment, in turn, has implications for defensive and offensive or retaliatory doctrine.

In this section, we report on our examination of Soviet and U.S. defensive capabilities in terms of decontamination and detection, individual and collective protection, and the number and organization of personnel involved in chemical warfare defense. Our major finding is that more is known about Soviet defensive than offensive capability and that, therefore, comparisons of U.S. and Soviet defensive capabilities can be made with greater confidence than comparisons of their offensive capabilities. The comparison between the United States and the Soviets that is most favorable for the United States concerns the ability to protect individuals. Other comparisons about defense are less favorable, with the Soviets appearing to have built a strong defensive capability for nuclear, biological, and chemical warfare.

What are the Soviet decontamination and detection capabilities?

The literature indicates that the Soviets have an impressive chemical detection and decontamination system. It rests on their having developed a wide array of equipment whose distribution is widespread throughout the military services.

Knowledge review

There is a great deal of credible information on Soviet protective measures. Robinson (1978) suggests that the Soviets have made a conscious effort to publicize their protective capacity, and for support he points to articles in Soviet military journals and even to Soviet press agency photographs of Soviet forces conducting decontamination drills. SIPRI (1973) cites more than twenty Soviet publications containing technical information on available equipment protected against biological and chemical warfare. Additionally, information obtained from analyses of Soviet equipment captured in the 1967 and 1973 Arab-Israeli wars proved to be an intelligence bonanza. The most recent and detailed sources of information we used are Crelling (1979) and Westerhoff (in Defense Intelligence Agency, 1980), both unclassified. Crelling draws on a large number of unclassified reports from American and Eastern and Western European military journals showing photographs of Soviet detection gear and decontamination equipment. The DIA report, while it is detailed, is less useful in having no source citations or other indication of the data it is based on. Classified studies, such as a 1980 Institute for Defense Analyses study (Kerlin, 1980) and the 1981 Defense Science Board study, are less detailed but concur with Crelling and DIA.

What are these findings? In essence, the findings are that the Soviets are prepared for chemical warfare decontamination of personnel, personal clothing and equipment, small arms, tanks and armored vehicles, and terrain. DSB and DIA, relying on information supplied by DOD, credit the Soviets with having thousands of reconnaissance and decontamination vehicles for chemical warfare. Crelling, DIA, DSB, and IDA all take note of Soviet power-driven decontamination equipment, including truck-mounted decontamination tanks (ARS-12 and ARS-14); truck-mounted water and steam decontamination systems (DDA-53); and jet-engine-powered heavy-equipment decontamination systems (TMS-65). DIA describes Soviet mobile decontamination stations with truck-mounted steam and hot-air generators, drying and showering tents, and collapsible water tanks. The IDA study concludes that, with this type of equipment, Soviet chemical warfare divisional defense teams could decontaminate more than combat vehicles and almost troops an hour--compared with the U.S. ability to decontaminate vehicles and troops an hour.

As for the Soviets' detection capability, Crelling and DIA indicate that it rivals their decontamination capability. Both note that detection and identification kits are available that respond to V-nerve agents, G-nerve agents, and other lethal agents (mustard, hydrogen cyanide, lewisite). Crelling says this equipment is compact, reliable, and easy to operate.

Observations

Debate focuses not on the Soviet ability to defend but on what it means. For example, Hoeber (1981) argues that the buildup of Soviet decontamination capability, given the relative U.S. weakness in waging chemical war, seems motivated not merely to fulfill defensive requirements but also to enable Soviet troops to exploit the offensive advantages of their chemical weapons. Others have noted that the Soviet emphasis on chemical warfare defense is not inconsistent with a doctrine of combined arms combat.

What is the Soviet capability for protecting individuals from lethal chemicals?

According to the literature, the Soviets have developed suits and masks that protect their troops from known chemical agents, and they have distributed garments widely to their field units. Both the suits and the masks have limitations.

Knowledge review

Much credible information exists on Soviet protective measures, including protective clothing. In general, the sources we reviewed (among them Center for Defense Information, 1980; Crelling, 1979; DSB, 1981; Hoeber, 1981; Robinson, 1978, 1980; Robinson and Meselson, 1980) agree that the Soviet mask and

clothing are efficient in shielding their wearers from toxic chemicals but burdensome in other ways. The sources indicate that the protective clothing is made from impermeable rubberized fabric that produces heat stress even in moderate temperatures. Robinson (1980) reports that at about 60 degrees Fahrenheit the clothing can be worn only for about 4 hours before heat stress builds to casualty levels, and above 70 degrees the tolerance is for less than half an hour.

The most authoritative source on the quality of Soviet chemical warfare suits and masks is

Observations

Kallis (1980) notes that the Soviets may use rubberized suits because they perceive the United States and NATO as not able to make a persistent agent threat and, thus, Soviet troops would not have to remain long in a protective posture. However, if the United States and NATO were to develop their ability to use persistent agents, they might become able to affect Soviet troops severely. The overall threat could be strengthened by the ability to locate and destroy decontamination stations and equipment. This raises the question of whether such tactics are being considered in operational planning.

What is the Soviet capability for collective protection?

For armored fighting vehicles, collective rather than individual protection can be provided. The Soviets' ability to provide collective protection for armored combat vehicles is rated high by sources we reviewed. There is some question about the reliability of the systems in combat conditions.

Knowledge review

As with other Soviet protective measures, there is much credible information on collective protection. Crelling (1979), for example, draws on open sources from Eastern and Western Europe, also citing military journals and training manuals. Among classified reports, Miller (1980) and IDA (Kerlin, 1980) are valuable in that they cite intelligence sources. We assume--the reports do not make it clear--that these sources drew their information from captured Soviet equipment.

The sources indicate that many Soviet tanks have seals and positive-pressure filtered-air supplies, so that their crews are

fully protected without having to wear masks. Chemical, biological, and radiological protection is specifically identified for the T-64 and T-72 tanks (and probably the T-80 tanks under development) and armored personnel carriers. The Center for Defense Information (1980) and DIA (1980) note that some Soviet tanks have protection only from radiation, not from chemical agents, but the basis for their statements is not clear. For tanks with collective protection against chemical warfare, Miller (1980) raises the question of how well the seals would hold under the stress of high speeds and continuous firing.

Observations

To what extent are Soviet personnel allocated to chemical warfare defense?

The Soviets are reported as having a special branch of military forces, the Soviet Chemical Troops, devoted to chemical, biological, and radiological defense. Estimates of its size vary, but facts about its integration into the overall Soviet military forces are known.

Knowledge review

Hoeber (1981) states that Soviet chemical warfare troops consist of units and subunits responsible for chemical warfare defense--that is, for decontamination of personnel, weapons, equipment, structures, and terrain exposed to radioactive and chemical agents; for radiation and chemical reconnaissance; and for identification of enemy sites and other targets for chemical attack. The sources we reviewed seem to have based their estimates of the total size of these troops on published statements of Soviet structure and staff levels. However, the estimates have a broad range, with DIA (1980) indicating 50,000 troops, the 1982 classified DOD report to the Congress indicating 60,000 troops, and the 1981 classified DSB report giving a high estimate of 100,000 troops. All sources state that these troops are integrated into every military unit--ground, air and missiles, navy and so on--of every size, including divisions, line regiments, and companies.

Observations

The Soviet chemical, biological, and radiological defense units seem to have promoted defensive assimilation within the entire military organization. This might limit the effectiveness of a U.S. chemical retaliatory threat that had producing

casualties as its goal. It would also limit the deterrence value of that threat.

Summary

The information from which to determine what is known about the Soviet defensive capability is strong, partly because the Soviets have released information and partly because equipment was captured in the Arab-Israeli war. The overall picture is one of a methodical preparation to defend against chemicals, biological weapons, and radiation. The main question that arises is, given Soviet defensive strengths and weaknesses, particularly in collective protection and combat stress, what objectives are reasonable for a U.S. retaliatory chemical strike?

What are the U.S. decontamination and detection capabilities?

Our review indicates that the lack of an adequate U.S. capability in chemical agent detection and decontamination has caused concern among U.S. defense analysts.

Knowledge review

In examining U.S. capabilities in detection and decontamination, we relied heavily on three recent classified documents. One is based on information obtained from a series of intelligence briefings (DSB, 1981). In most cases, however, its direct sources of information are not clear. Another, by the American Defense Preparedness Association (ADPA, 1980), is a collection of symposium reports on nuclear, biological, and chemical warfare defense. It is particularly useful because the reports were prepared by some who were responsible for conducting research in these areas and by others who were responsible for using the detection and decontamination equipment. The third source, an Army Science Board study (1979), summarizes the findings of the panels that had been commissioned to assess the status of U.S. Army chemical warfare decontamination capability.

What can we conclude about U.S. capabilities in these areas? Table 8 on the next page, giving data on the relative U.S. and Soviet capabilities, shows that the United States does not match the Soviet decontamination capability. Table 9 the next page displays the Defense Science Board's subjective estimates of current and future U.S. defense against chemical warfare for each service. For decontamination and detection, most services are shown as having marginal capability,
. (We discuss this more fully in chapter 4.)

Observations

The problems with the limited U.S. detection and decontamination equipment raise the question of whether the United States is technologically inferior to the Soviet Union in developing

Table 8

A Comparison of U.S. and Soviet Standard Decontamination Equipment

Equipment type	U.S.S.R.	U.S. counterpart
Skin therapy	IPP-V	M258 injector (M13)
First aid skin and clothing	Khs	None
Personal equipment	IDP	M258 (M13)
Small-scale	RDP-4	M11
Large-scale	DK-4	None
	ARS-12	M12AL
	DDA-53	Partial (M12A1)
Clothing station	AGV-3M	None
Rapid vehicle	TMS-65	None
Small weapons	PM-DK	None
Large weapons	A-DK	None

SOURCE: Army Science Board, Chemical Decontamination/ Contamination Avoidance, Vol. 2, Appendices, SECRET (Washington, D.C.: May 15, 1979), p. 39.

detection and decontamination devices or whether it has been indecisive or confused in trying to resolve the problems. We indicated in a recent report that technological problems and the lack of strong central planning and direction in the chemical warfare program are part of the difficulty (GAO, 1982).

Table 9

U.S. Protection Capability by Planned Acquisition of Material 1981-86[a]

Critical area	Air Force	Army	Marine Corps	Navy
Detection and alarms				
Individual protection				
Collective protection				

SOURCE: Defense Science Board, Report of the Defense Science Board Summer Study on Chemical Warfare, SECRET (Washington, D.C.: Office of Under Secretary of Defense for Research and Engineering, January 1981), p. 46.

[a]M = marginal with inadequate forces coverage and no sustainability; S = satisfactory with ability to survive and sustain acceptable combat operations; Z = zero-to-limited operational capability.
[b]Reflects inadequate technology base and procurement.
[c]Panel urges special attention to this area.

What is the U.S. capability for protecting individuals from lethal chemicals?

The literature gives the U.S. protective ensemble both high and low ratings. Our review indicates that, in relation to Soviet gear, the U.S. protective clothing is quite good but that, in terms of what the services want or believe they need, there is much yet to be obtained.

Knowledge review

The current U.S. mask-and-suit ensemble has been called the best in the world (Henry in ADPA, 1980). Open sources such as reports by Robinson (1978) and Meselson and Robinson (1980) rate U.S. ability high on protective gear and use this assessment to support arguments that the ability to defend deters chemical warfare. These expert opinions are backed up, as we noted previously,

(Army Combat Developments Experimentation Command, 1976). The 1981 DSB report indicates, even though the information source is unclear, that the U.S. suits can be worn for 14 days consecutively and still provide the required minimum 6 hours of protection against chemical agents.

However, many other sources describe problems with the U.S. protective ensemble. At a general level, the 1981 DSB study concludes, as we saw in table 9, that the Army and Air Force have ability to protect individuals and that the ability of the Navy and the Marine Corps is . It is not clear, however, what criteria and data DSB used in making its assessment. The 1980 American Defense Preparedness Association symposium provides a more detailed analysis from the perspective of the people who develop, test, and use the protective gear. Smith, for example, identified eight specific problems with the current U.S. garment: (1) it cannot be laundered, (2) it is not flame resistant, (3) it is difficult to put on and remove, (4) it hampers manual dexterity, (5) it is excessively bulky, (6) it is incompatible with some other equipment, (7) it is not designed to allow the performance of bodily functions, and (8) it creates a logistics burden. As for the mask, Robinson in the same symposium indicated that a new chemical warfare mask is needed that, first, does not limit its user's vision when aiming the M-16 rifle, using sighting devices, and reading optical displays and, second, does not cause difficulties in changing its filters. Cauller at that symposium said that a new mask requires a flexible lens, external filters that are easy to change, a periphery turned inward to improve the way it fits, and a standard facepiece that satisfies air and tank crew requirements as well as special applications. (We discuss the development of new protective garments and masks in chapter 4.)

Observations

The equation governing the satisfactory status of individual protective gear for chemical warfare cannot be judged independently of other defense issues, such as decontamination and detection. For example, it may be less important that the suit and mask be easy to put on if detection capability is excellent than if it is poor. A question arises as to how well strategies for improving defense are being coordinated in the services.

What is the U.S. capability for collective protection?

Progress in equipping U.S. combat vehicles with collective protection has been , according to classified sources. We found no consistency in the reasons that are given.

Knowledge review

As we saw in table 9, the 1981 DSB study found

, but the sources provide different explanations for it.

The DSB study states, without specifying the information source, that the technology for collective protection exists and that the problem appears to be one of procurement. However, in the 1980 ADPA symposium, composed of both equipment developers and users, Scott noted that there are some technical problems in collective protection, including the need to indicate the remaining life of the chemical agent filters, the need to have a way of rapidly entering stationary collective protection shelters in contaminated areas, and the tradeoff in power requirements among smaller air-filtration systems. Robinson (1978) indicates, without referring to his source, that some U.S. military analysts do not favor collective protection in tanks--not, at least, the positive overpressure system that is pursued by the Soviets--and prefer a ventilated faceplate system that allows each crew member to have a mask whose air is filtered from a central source.

In our review, we did not find sources that detail the extent to which U.S. combat vehicles such as tanks and vans have been designed or can be fitted with collective protective systems or the costs of doing so. We found little specific information on the extent to which mobile collective protection units are available to the services. The Army was directed in 1977 by Public Law 95-79 to improve collective protection for U.S. armored vehicles. A 1980 paper by the U.S. Army Chemical System Laboratory on nuclear, biological, and chemical collective protective systems for combat vehicles presented the following findings from its testing and evaluation program:

--

(English in ADPA, 1980, p. 30).

Observations

Alternative means for collective protection include positive overpressure systems and ventilated facepieces. If the United States adopts positive overpressure systems, then like the Soviets it would seem to have the problem that crew members who exit vehicles into a contaminated environment contaminate the vehicle interiors when they return. However, positive overpressure is said to allow crew members to sit more easily and to read optical displays better than if they were forced to wear ventilated facepieces. One question arising from our review is that of the criteria that have been used for deciding one way or the other. Other questions are what technical problems remain in collective protection for the several services and what systems have to be fitted with collective protection and at what costs.

How many U.S. personnel are allocated to chemical warfare defense?

Several recent classified reports indicate that the United States should increase the number of personnel who work in chemical warfare defense. The criteria for establishing "adequate" force levels are not clear, however.

Knowledge review

The 1982 DOD report to the Congress indicates that DOD has no intention of matching the large Soviet chemical force structure but believes that there is a need to increase the number of U.S. forces and units dedicated specifically to chemical warfare defense. The numbers have been increasing--according to the DOD report, the Army increased the number of its chemical warfare specialists from 1,600 in the mid-1970's to 7,400 in fiscal year 1982--but not sufficiently to achieve DOD's stated goal. DOD's goal is to make, presumably, each service able to operate for in a chemical warfare environment. For the Army, this apparently means chemical specialists by the end of

fiscal year . None of the sources we reviewed indicated what measures tell when a capability has been attained.

The 1981 DSB report notes the opinion that the Army is short of chemical warfare personnel above the division and corps levels. The report does not, however, specify the basis for this view or expand on other services' needs for chemical warfare personnel.

Observations

We did not find stated criteria for establishing adequate numbers of chemical specialists so that each service can operate for during chemical warfare. If these criteria are to be developed, it should be done in conjunction with the other aspects of defensive capability, such as detection and decontamination, and, if retaliation is envisioned, in conjunction with aspects of retaliatory capability as well.

Summary

Much reliable information is available on U.S. defensive equipment and personnel but some questions have few answers. The overall picture is that the United States, unlike the Soviets, has not built a strong ability to defend against nuclear, biological, and chemical warfare. We question the extent to which plans for improving in these areas include the coordination of the different components of defensive equipment and personnel, doctrine, and training and how we may know whether implementing them will give the United States an adequate defensive or retaliatory capability.

HOW AND TO WHAT EXTENT HAVE THE UNITED STATES AND THE SOVIET UNION PREPARED FOR IMPLEMENTATION?

The ability to engage in chemical warfare requires, according to Robinson (1980), that chemicals be viewed as a means for fighting war. It also requires a chemical warfare doctrine that has been adequately developed, fully assimilated into the military forces, and integrated with the overall tactical plan. Training in execution of the doctrine must be consistent with its status within the overall tactical doctrine. Command, control, and communication must be attuned to chemical warfare. A large chemical warfare organization may look impressive, but unless the rigors of the battlefield have been adequately planned for, the ability to fight a chemical war will not exist.

It is difficult to distinguish a potential threat from the actual ability to wage war unless the extent to which military forces are prepared can be determined. To the degree that the Soviets have developed an ability to engage in defensive and offensive chemical warfare, a threat may exist for U.S. and NATO

forces. In this section, we compare and contrast what is known about U.S. and Soviet implementation capabilities in training, logistics, and deployment.

The literature shows widespread belief that the Soviet Union has assimilated chemical warfare and that the United States has not. The belief is based on the differences in Soviet and U.S. training for operating in a toxic environment. However, little is known about Soviet offensive deployment and offensive logistics. Our review of available information raises the question of whether the Soviets are as well prepared as they are commonly perceived to be.

How and to what extent has the Soviet Union prepared?

The classified literature uniformly assesses the Soviet ability to implement chemical warfare as being high. Only a small portion of the open literature questions that ability.

Knowledge review

Supporting the view that the Soviet military forces have assimilated chemical warfare preparedness, a number of sources observe that Soviet training for chemical warfare is impressive for specialist and nonspecialist troops alike (Crelling, 1977; Dick, 1981; Westerhoff in Defense Intelligence Agency, 1980). On the whole, they do not cite their sources. In some cases, however, the information they present is so detailed that the sources appear to be Soviet training manuals. Crelling and Westerhoff and Verna (1977), for example, give details of the training in Soviet military academies. Some reportedly grant doctoral degrees, and all are said to require extensive knowledge of defensive equipment, lethal agents, and general engineering and military material. Crelling cites Soviet military journals in addition to open Western military and technical literature. Westerhoff provides no citations but describes in detail the Soviet curriculum for defense against chemical warfare. He states that it covers self-protection; the administration of antidotes; decontamination; the recognition and detection of chemical agents; the operation of chemical, biological, and radiological measuring and monitoring instruments; and procedures for warning troops of chemical, biological, and radiological attack. Verna states that there are nineteen known chemical schools and training areas in the Soviet Union but does not cite a source for this information.

The strength of Soviet defensive training reportedly stems from repetitive drills and classroom work (Crelling, 1977; Westerhoff, 1980) and realistic combined arms tactical exercises in protection (Erickson, 1978; Westerhoff, 1977), even to the point of occasionally using diluted lethal agents (DOD, 1982; DSB, 1981; Verna, 1977; Westerhoff, 1980). Erickson (1978)

indicates that the Soviets have about training ranges for chemical warfare and regimental exercises, although there is no citation of sources.

The Soviet military organization we described in our section on defensive equipment and personnel is frequently presented as evidence of the Soviet assimilation of chemical warfare doctrine (Crelling, 1979; Dick, 1981; Erickson, 1979; Hoeber and Douglass, 1978; Strategic Studies Institute, 1981a, b). Another support of implementation capability is said to be production capability. Crelling reports a 1962 statement by a senior U.S. naval official that the Soviets have chemical plants,

. More recent information from classified reports,

. DSB (1981) indicates, presumably on the basis of an intelligence briefing, that

. The 1982 classified DOD report to the Congress indicates further

Robinson (1978, 1980) asserts that the disparities between the Soviet Union and the United States may not be as great as commonly believed. He bases the argument partly on the lack of knowledge about offensive Soviet chemical warfare preparations. His 1980 review of the open literature leads him to question whether the United States and the Soviets are not evenly matched on some implementation factors, whether the information that is available (including secret literature) allows detailed comparisons, and whether asymmetry is only temporary and would give way with the rapid improvement now being made in U.S. anti-chemical capabilities.

We found no definitive answers to Robinson's questions. Dick (1981) and others note that there is plenty of evidence that the Soviet chemical warfare posture is deficient in important respects while the Soviets are still in a much better position than the United States. The 1982 DOD report notes

Observations

How and to what extent has the United States prepared?

We found general agreement that the U.S. ability to react to a chemical warfare attack is improving .

Knowledge review

The U.S. military has been severely criticized for its lack of realistic training exercises (DSB, 1981; Hoeber, 1981). DSB observes, for example, that training has been provided and emphasized in the individual services but that combined and coordinated chemical warfare arms operations have not been emphasized. DSB lists other areas of training neglect: weapons delivery while suited, medical support to the injured while military operations continue, decontamination procedures with realistic time requirements, and the continuity of command, control, communications, and intelligence activities. The study also indicates that more attention should be given to joint training and logistics exercises with simulated contamination.

Many sources also note, however, that U.S. training is rapidly improving. DSB expressed its belief that all the services except the Navy would be satisfactorily trained in chemical warfare if the present training plans were followed. Lenorovitz (1979, 1980) and Donnelly (1981) point to U.S. and NATO training improvements, including the fact that Army basic training in nuclear, biological, and chemical warfare has been increased from 4 to 14 hours. Still, no sources we reviewed give U.S. forces credit for more realistic training.

We recently completed a review of the readiness of U.S. forces to carry out their missions in a chemical war (GAO, 1982). The review involved fieldwork at key DOD service headquarters, field commands, and subordinate organizations and units in the United States and Europe. We found that the commanders of the services show varying degrees of enthusiasm for chemical defense preparedness, primarily because they do not all believe that it is worth the resource costs. We found that chemical warfare training in some units was slighted for other types of training and that trained personnel were not always being used in their specialty areas. Thus, questions still remain about whether U.S. training is adequate and of sufficient quality.

If the United States were to be able to respond rapidly to chemical attack with a retaliatory chemical strike, deployment would be a key issue. In our comparison of Soviet and U.S. munitions capabilities, we indicated that the U.S.

stockpile is located in the continental United States even though

. Although the NATO countries have agreed in principle to the need to defend against chemical warfare and although they have the legal right to retaliate with chemical weapons, none is actively calling for deployment within its boundaries. In fact, there is a long history of general distaste among most European nations for chemical warfare, and there is no indication that it is likely to change.

As we stated in a previous report (GAO, 1977), Army officials have told us that moving chemicals by surface from the United States to Europe would take days, although the Joint Chiefs of Staff estimate , given certain planning assumptions. We also noted that the Army's consumption rates indicated that it would require about

. DSB (1981)

Observations

Many sources criticize U.S. chemical warfare training exercises for their lack of realism and for their failure to be coordinated with other services. We note, however, that until each service possesses developed and integrated chemical warfare doctrines, realistic training will not be possible.

Summary

Most sources we reviewed basically agree that the United States does not currently have the ability to fight in a chemical war, although some are less pessimistic than others about the progress being made. The U.S. inadequacies are well documented. A Soviet ability to engage in chemical war is frequently asserted, but we found little documentation to support the assertion except in the area of training. Questions remain unanswered on the extent to which the Soviets could wage chemical warfare.

SUMMARY AND CONCLUSIONS

The literature shows no doubt that the United States lacks a credible chemical warfare deterrent. Perceptions reflected in the general literature and the data agree that the United States does not have the means to respond effectively to a chemical attack. In contrast, the general literature reflects a perception that the Soviets are highly capable of waging chemical warfare, but the evidence to support the perception is neither strong nor plentiful. We did not investigate the willingness of

either the Soviet Union or the United States to use chemical weapons, but we take note that belief in a nation's ability to fight in a chemical war seems to be a condition for the belief in its willingness to use chemical weapons.

Little is known about the Soviet offensive capability. The literature indicates in a general way that the Soviet doctrine on chemical warfare is well developed and that the U.S. doctrine is not. We have questions about the high marks that have been given to Soviet doctrine, but evidence supports the belief that U.S. doctrine is inadequate. We have many questions about what specific elements of doctrine should be developed.

Classified sources attribute the

. As for the U.S. stockpile, we question whether U.S. retaliatory capability has been validly assessed. We also question the accuracy of statements about current U.S. worldwide chemical warfare requirements (given our review of a simulation study). The general literature indicates that, unlike the Soviet Union, the United States does not have a long-range chemical weapons delivery system.

As for defensive equipment and personnel, much reliable information is available. The overall picture is that the United States, unlike the Soviet Union, has not built a strong ability to defend against nuclear, biological, and chemical warfare. An important question is the extent to which plans for improving capability in these areas are coordinating the several components of defensive equipment, personnel, and other capability factors.

Finally, we found that the U.S. inadequacy for fighting in a chemical war has been well documented. We found little documentation to support assertions about the Soviet ability except in training. There are many unanswered questions about the extent to which the Soviets could wage chemical warfare.

CHAPTER 4

HOW CAN THE UNITED STATES MODERNIZE ITS CHEMICAL WARFARE SYSTEM?

Drawing on the recommendations in the Defense Science Board's 1981 report on chemical warfare and in other DOD-sponsored studies, DOD proposed a modernization program for chemical warfare to the Congress in 1982 (DOD, 1982). The implicit purpose of the modernization plan is to improve the ability of the United States to deter chemical warfare. The plan may improve perceptions about both ability and will. In this chapter, however, we investigate the extent to which the plan will affect not perceptions but actual ability. We raise three questions about the modernization program. What are the factors of modernization, apart from the chemical weapons? Are there alternatives to the procurement of binary weapons? Do binary weapons offer substantial advantages over unitary weapons? The number of sources on modernization is small, they are variable in quality, and issue reviews and opinions predominate over tests and evaluations.

DOD has identified what has to be considered in modernization, but our review indicates that DOD's plans may not be sufficient. In some cases, we find little evidence that DOD's modernization efforts are comprehensive or integrated. The DOD proposal is only one point on a continuum of possible alterna-

QUESTION	SUBQUESTION
1.0 How is chemical warfare deterred?	1.1 What is a credible deterrence capability? 1.2 What are the different ways of deterring chemical warfare? 1.3 How has the United States chosen to pursue deterrence?
2.0 How do the United States and the Soviet Union compare in chemical warfare capability?	2.1 What are the U.S. and Soviet doctrines governing the use of chemical weapons? 2.2 How does the U.S. chemical stockpile compare with the Soviet Union's and how is stockpile need determined? 2.3 How do the U.S. and Soviet chemical warfare delivery systems compare? 2.4 How do the United States and the Soviet Union compare in defensive equipment and personnel? 2.5 How and to what extent have the United States and the Soviet Union prepared for implementation?
3.0 How can the United States modernize its chemical warfare system?	3.1 What factors are necessary for modernization? 3.2 What are the alternatives to binaries? 3.3 Do binaries have substantial advantages over unitaries?
4.0 How does modernization affect the prospects for disarmament?	4.1 How successful have chemical warfare disarmament efforts been? 4.2 What are the verification problems in banning chemical weapons? 4.3 What implications does modernization have for disarmament?

tives. Few sources have attempted to determine either what to expect given alternatives to produce or the relative merits of the several alternatives in the event of a chemical war. Open-air testing of binary weapons has been precluded since 1969 by Public Law 91-441. We find that assertions about the specific technical and operational characteristics of binary weapons are, therefore, not securely supported by empirical evidence and must be recognized as possibly inaccurate. The lack of data also prohibits conclusive comparisons about the performance of binary and unitary weapons. There is consensus that the design of binary weapons helps make them safe for handling, storing, and transporting in peacetime, but these peacetime advantages may have some related wartime costs that are not often discussed.

WHAT FACTORS ARE NECESSARY FOR MODERNIZATION?

We have compared the Soviet Union and the United States on their capability for chemical warfare with regard to doctrine, stockpile, delivery systems, defensive equipment, defense personnel, and implementation, or troop training and weapons deployment. Taken together, these factors can be said to determine a nation's overall ability to operate in a chemical war, retaliate in kind to a chemical attack, and deter an adversary from engaging in chemical warfare. Attempts to modernize, however, must identify for each factor what additional effort is required and take the appropriate steps to begin that effort. Relatively few sources conceptualize either the perceived or the actual ability to engage in chemical warfare as a combination of factors rather than merely a weapons capability. In chapter 3, we outlined problems and deficiencies for each factor for the United States and the Soviets. In this first section of chapter 4, we report on what is known about procedures, planned and under way, for modernizing the U.S. capability with regard to each factor. (We exclude stockpile from the discussion of factors in this section but include it in the discussion of binaries in the rest of the chapter.)

Knowledge review

Doctrine

If a weapon system is to be valuable to its users, there must be a clear and precise understanding of when and how it will be used. As we have seen, U.S. chemical warfare doctrine--joint doctrine, doctrine for integrated battlefields, and doctrine for the individual services--does not address several specific questions that should be answered. After finding many deficiencies in this area in our 1977 review, we recommended that, as long as DOD maintains a chemical munitions stockpile, the Secretary of Defense should develop and document procedures for using it as a deterrent in the most effective way (GAO,

1977). DOD supported the recommendation but pointed to many constraints in following it. DOD's most recent response to criticisms about doctrine states that

> "The reestablishment of the Army Chemical School at Fort McClellan, Alabama, in FY 1980 is a vital part of the program to develop chemical warfare doctrine. All services are now involved in improving and developing chemical warfare operational concepts." (DOD, 1982, p. VIII-5, emphasis added)

It seems that little progress has been made since our 1977 report. This may be because developing chemical warfare doctrine is very difficult, but given that the United States has had chemical weapons for decades, doctrinal deficiency is clearly a cause for concern. The lack of progress raises serious questions about the procurement of chemical weapons:

--What obstacles have made the development of chemical warfare doctrine so difficult? Can they be overcome?

--Is DOD addressing the issue of doctrinal development appropriately for insuring success?

--Will producing and procuring more modern chemical weapons make it possible to develop the necessary doctrine?

--Should money be allocated for production and procurement before the appropriate doctrine has been developed?

We stated in our 1977 report that if DOD was constrained from following our recommendation, then the need to maintain a chemical stockpile should be reevaluated.

Delivery systems

The United States is essentially limited to short-range chemical weapons systems. The range of its 155-mm and 8-inch howitzer projectiles is only up to 22 kilometers. Many of the sources we reviewed called this a serious deficiency. For example, DSB recommended concurrent production of chemical-filled bombs and 155-mm projectiles after examining DOD's 1980 plan to produce 155-mm projectiles first, then 8-inch projectiles, and finally the Bigeye bombs.

DOD did not adopt DSB's recommendation. DOD decided instead to forgo the 8-inch projectile and produce the 155-mm

(GB-2) projectile in 1984 and the Bigeye bomb (VX-2) in 1985 (DOD, 1982). Other research and development programs for retaliatory weapons are reported as being considered or under way and include the multiple launch rocket system and the 8-inch howitzer. However, our review indicates that the air-delivered chemical-filled bomb is the only long-range retaliatory weapon that will be available to the United States for the near future. Our review also raises many unanswered questions about DOD's reliance on the Bigeye bomb:

--Has the timetable for producing it been coordinated with its technical development?

--What is the expected effectiveness and longevity of the aircraft required for using it?

--Are there constraints on its operation?

--What other ways of improving the U.S. long-range capability has DOD considered?

--How does any improvement in long-range capability relate to the doctrinal and deployment issues?

Defensive equipment

The United States, unlike the Soviets, does not have a strong ability to defend against chemical warfare. The sources we reviewed generally agree that the United States needs to improve its defensive capability in decontamination and detection, individual and collective protection, and personnel. DOD is attempting to do this. According to the budget plan for fiscal 1983-87 for chemical deterrence, about two-thirds of the estimated $6 billion to $7 billion that DOD requires will be devoted to defensive protection. The Office of the Under Secretary of Defense for Research and Engineering indicates that DOD is procuring, for delivery to the field, individual garments, automatic alarms, decontamination equipment, detection kits, field shelters, collective protection items, and individual filter units for armored vehicles. Furthermore, DOD is researching and developing improved equipment in all critical areas. We found manifest progress, but we also noted some continuing problems and limitations.

Detection and decontamination. The literature indicates that detection capability has been improved recently: the newly developed M256 chemical detection kit and the M8 series of chemical alarms present the first automatic detection capability in Western inventories. Both items have operational problems. The M8 has been described as being less sensitive and slower than it should be and as creating a logistics burden with its servicing requirements; the M256 has been described as taking too long to operate (ADPA, 1980).

Even if these detection devices had no problems, neither one would provide remote-area sensing. DSB (1980) and the independent civilian Association of the United States Army (1980) say that the military should have this capability. According to Gamson in the American Defense Preparedness Association symposium (ADPA, 1980), the advanced development of a remote-sensing device has begun, but last year we reported that

(GAO, 1982).

The American Defense Preparedness Association and the Army Science Board, both reliable sources, indicated in 1980 that DOD's efforts to improve decontamination are focused on developing a jet-powered decontamination device; researching water-based, interior surface, and noncorrosive special-application decontaminants; and developing mobile decontamination equipment and a series of kits for the partial decontamination of skin, clothing, and weapons. These efforts are needed, and that they are points out the shortcomings of present procedures and equipment. The literature shows, for example, that better decontaminants and application methods are needed for cleaning equipment quickly and completely, with less labor in less time, and with efficient support from engineers in controlling the large volumes of runoff water and in preparing the decontamination sites (Curtis in ADPA, 1980).

Individual protection. New protective suits and masks are being developed, but last year we reported that technical limitations mean that the new ensemble will reduce but not eliminate the problems of the older one (GAO, 1982). The new mask is superior to the old, but the flexible lens material and lens bond still pose problems. The protective clothing will hamper performance less but only marginally and not until late in the 1980's, unless technology leaps forward unexpectedly.

Collective protection. All the sources we reviewed agree that the services have between zero and limited ability in collective protection. We were told by DOD that plans for improvement are being developed, but we saw none that delineate efforts to provide collective protection for present or future combat vehicles. We found no mention of plans for protecting civilian populations.

Defense personnel

The classified reports agree that the United States needs to increase the number of personnel in chemical warfare defense and that DOD is working toward making defense forces able to sustain operations in a chemical war. According to the 1982 DOD report to the Congress, each service is developing its own force structure. The Marine Corps plans "to fully man" nine established nuclear, biological, and chemical defense units by the end of fiscal year . The Army aims to have chemical specialists by fiscal . The Air Force plans to add

about members to its chemical warfare defense-related staff by fiscal 1987. It now has 850 members in a "disaster preparedness" specialty. The Navy has no plans to augment its forces, which now include hull technicians with some chemical defense training. The criteria that were used for establishing these numbers as "adequate" force levels for chemical war are not clear in the report.

Our review leaves us with the following unanswered questions about decontamination and detection, individual and collective protection, and defense personnel:

--How will civilians be protected? At what cost? Is the U.S. ability to deter chemical warfare credible if civilians are not to be protected?

--Is individual protective gear being researched, developed, and managed appropriately? Is it being effectively coordinated among the services?

--Does DOD have plans for controlled studies from which to collect data that would permit a valid estimate of the numbers of U.S. chemical defensive troops needed to operate successfully in chemical warfare?

--Can new and existing military vehicles be equipped with antichemical defenses? At what cost? How would the additional equipment affect the operation of the vehicle?

Implementation

The U.S. military has been uniformly criticized for having no realistic or adequate training and exercises for chemical warfare. We described some recent improvements in chapter 3, and the 1982 DOD report to the Congress identifies some plans for the future. The report states that training will be standardized as much as possible, facilities will be improved, joint exercises will include scenarios that have chemical operations, and standards for testing the performance of units and individuals in contaminated environments will be established.

Despite finding evidence that DOD is taking some steps to remedy the deficiencies, we found no reference to the ways in which DOD plans to monitor the steps or assess their progress. Among the unanswered questions we find:

--Exactly what training is required for chemical warfare and how is this determined?

--How does DOD plan to connect training to doctrine, operational concepts, tactics, and military objectives?

--What plans does DOD have for evaluating the services' training programs for chemical warfare?

"Our NATO allies have been informed of our intent to improve U.S. retaliatory capabilities. This U.S. decision involves development and production only. Our allies have also been informed that no decisions or recommendations have been made regarding deployment of chemical weapons. Should it ever be determined that overseas deployment is desirable, there will be full consultation with the nations involved prior to making any decision." (DOD, 1982, p. I-6)

In 1977, we reported that "

" (GAO, 1977, p. 41).

We find no evidence that convinces us that these earlier findings are no longer valid, having found no plans to improve deployment, and we continue to be concerned that important questions we raised 6 years ago have still not been answered:

--When does DOD plan to resolve deployment issues in consultation with the NATO allies?

--What steps are being taken to decrease the costs in time and resources required to move chemical weapons from the United States to a NATO battlefield if forward deployment is not possible?

--Is it true that little or no improvement is possible in the overall U.S. retaliatory capability without a great change in deployment that would permit stockpiling more chemical weapons in Europe?

Observations

We have emphasized throughout this report that chemical warfare capability is made up of many factors. We have presented each one separately and we have discussed their relationships. Chemical warfare capability must be viewed as a configuration of integrated rather than merely added parts. In examining training, for example, one must investigate how training is connected to doctrine, operational concepts, tactics, and military objectives.

In reviewing U.S. plans for improving its chemical warfare capability, we have looked for this type of integration and we have found little indication that plans for improving capability have been properly coordinated. The centerpiece of DOD's

modernization program is the replacement of chemical munitions. DOD recognizes that it must make new efforts to resolve problems in related areas and it has outlined some of them but we find no evidence that DOD plans to integrate them. DOD's progress seems slow and difficult and this raises some important questions:

--What hinders progress in each of the related areas and their coordination? What would appropriately remove the obstacles? Are some problems simply unresolvable at this time and can the reasons be stated?

--Can U.S. chemical warfare capability be improved if some of these problems cannot be resolved?

--What is the relationship between producing new chemical weapons and resolving the many problems (as in the development of doctrine and the deployment of weapons) that have persisted through the many years that the United States has had chemical munitions?

--Does overall capability depend so heavily on the resolution of any of these problems that, without it, no improvement can be made by procuring new weapons?

--Should DOD be expected to progress further toward the resolution of some of these problems before decisions are made about investing in the production and procurement of new chemical weapons?

Summary

Modernizing the U.S. chemical warfare capability requires the careful consideration and integration of several factors. The weapons are only one factor. Others are doctrine, stockpile, delivery systems, defensive equipment, defense personnel, troop training, and deployment. We find that the continued presence of known deficiencies in all and the failure to coordinate their correction could well mean that procuring new weapons alone will not improve the U.S. chemical warfare capability. The information we reviewed indicates that DOD has taken some steps to correct deficiencies and is planning others, but they are so recent that we are unable to determine their success. Moreover, we found little evidence that DOD's attempt to address certain deficiencies is either comprehensive or integrated.

WHAT ARE THE ALTERNATIVES TO BINARIES?

The modernization program DOD proposed in its 1982 report to the Congress calls for a significant improvement of the U.S. ability to defend against and retaliate in a chemical war. It calls for this improvement to be achieved with the production of new binary munitions. In this section, we report on our search

for answers to two questions: Are there alternatives to the immediate production of binary weapons? If so, have they been adequately analyzed and compared in a variety of likely scenarios? We found that DOD has posed only one of a number of alternatives and that few analyses have attempted to determine what the result might be of adopting other alternatives or even what their relative merits are.

The alternatives to binary weapons are tied closely to the different chemical warfare policies we outlined in chapter 2. There we presented three basic policy alternatives that represent the two ends and the middle on a continuum containing many variations. On the one end is the emphasis on arms control, a policy requiring no chemical retaliatory capability but the maintenance of some defensive capability until arms control is a reality. At the other end is the emphasis on weapons, a policy that focuses on a substantial chemical retaliatory capability and its intended deterrent effect. In the middle is the policy focusing on defensive capability with only a limited chemical retaliatory capability. In the literature we reviewed, many authors argue for one policy or another and, therefore, argue for different ways of modernizing. With all its arguments, this literature contains few analytical studies.

Knowledge review

Proponents of policies asserting that no chemical warfare retaliatory capability is necessary are discussed by Finan (1978), Nerlich (1981), Robinson (1978), and the Institute for Strategic Studies (1981), among others. The assumption of these policies is generally that a strong chemical defense plus a conventional or nuclear capability enables a nation to cause an adversary to believe that launching a chemical attack would have unacceptable consequences. This assumption holds even when there is no chemical weapons disarmament treaty, when negotiations toward a treaty are going forward, or when an existing treaty is being maintained.

Looking for evidence that would either support or challenge this assumption, we found many more arguments for and against it than analyses studying it. In fact, we found only two analyses, both conducted for the Joint Chiefs of Staff by the Institute for Defense Analyses. They simulated a 1979-80 U.S. and Soviet conflict as it might have occurred with existing capabilities (Kerlin, 1980) and the same conflict as it might occur in 1986, assuming resources projected to that time (Kerlin, 1981). In examining the simulations, we did not question the validity of the assumptions or the quantitative data on which the simulations were based but we did question some of the logic. The analysts for the JCS were very careful to delineate the assumptions on which they based their work; despite the limits of simulations, the two studies are the definitive work on the subject. The actual numbers in the studies are less important for our purposes than the implication of the differences between the

numbers. In other words, both of any two estimates might be wrong but the differences between them could be accurate; this being so, we need be less certain of the raw figures than of the credibility of what the scenarios portray.

The 1981 study set up scenarios that assumed a 1986 central European battleground with the Warsaw Pact as the aggressor against NATO and with NATO responding with various retaliatory options.

What about a nuclear response to aggression with chemicals?

In short, we do not have support for the assumption

. This raises the question again of whether a nuclear threat is credible. Would the Warsaw Pact nations, as aggressor, believe that the NATO nations would risk nuclear destruction to stop a chemical attack?

Proponents of policies stating that a limited chemical retaliatory capability is necessary in addition to a chemical defensive capability (among them Lyons, 1981; Meselson and Robinson, 1980; Robinson, 1981; SIPRI, 1973; and United Nations 1970), generally make one or more of the following assumptions:

--Good chemical warfare protection can make the chemical attack that is required to overcome that protection too intense to be militarily attractive, compared with other forms of attack.

--Chemical weapons must be used in combination with other kinds of weapons.

--An enemy can be forced into protective gear, and its attendant degradation of performance, with only a limited retaliatory capability, so that the enemy gains no advantage by initiating the use of chemical weapons.

--The supply of chemical munitions in Europe and within the continental United States, if it were refurbished and maintained, is sufficient to keep frontline Warsaw Pact forces, as aggressor, in full protective gear for a considerable time.

--An enemy that is dressed in full protective gear is more susceptible to suffering casualties produced by weapons other than chemicals, such as antipersonnel mines and conventional artillery, rockets, and bombs.

--Given logistics constraints, stockpiling more chemical munitions means that fewer conventional munitions will be available.

--There is an optimum mixture of chemical and conventional weapons required to continue to reduce an enemy's performance and produce casualties.

We examined the 1981 IDA study for findings that would either support or challenge these assumptions. The simulation included a situation in which conventional munitions were used and also a

). This combination of munitions reflects the policy of limited chemical retaliation.

. The study's conclusions thus do not support or challenge the assumptions unequivocally but, rather, they reinforce the fact that they are bound by particular circumstances and objectives.

Proponents of policies that emphasize weapons--that is, a substantial ability to retaliate in a chemical war--generally assume that the United States needs more chemical munitions than it has now and that these weapons should be binaries (Bay, 1980; Hoeber, 1981; Hoeber and Douglass, 1978, 1981). We found that very few sources discuss the alternative of producing new unitary weapons and they pass over it only briefly. The 1981 DSB report, for example, mentions this alternative only to reject it on the grounds of its being "politically unacceptable." DSB also indicates that the production facilities for this alternative no longer exist, making some reference to the costs of reestablishing them in time and money.

The 1981 IDA study (Kerlin, 1981) did not contain a scenario that includes more unitary weapons. However, the analysts did look at what would happen by adding binary weapons to the munitions stockpile and by varying the number of them. Total stockpile sizes chosen for analysis ranged from about
. The analysts did not investigate how the optimum mixture of chemical and nonchemical munitions changes as the quantity of binary munitions increases.

The 1981 IDA study leaves open several questions that arise from the issue of the mixture of munitions, in addition to the one about the relative effectiveness of unitaries. If the chemical warfare program has to procure an additional
agent tons of chemical munitions, does this mean that the requirement for nonchemical munitions can be reduced proportionately? Given the constraints of logistics in deployment, it seems that this question implies some very difficult choices about which weapons to stock. The choices require knowing the optimum mixture of chemical and nonchemical munitions by type and quantity.

Another question the IDA study leaves open is about the objective of producing casualties. The need for
is based on the requirement of creating a very high casualty rate among them, since the chemical munitions in the simulation represented only some percent of what it took to produce all the casualties in the conflict. The question is, Could the casualty rate be obtained more efficiently with a comparable increase in conventional weapons?

Finally, the IDA study leaves a question about civilian casualties unanswered. It indicates that between NATO and Warsaw Pact forces, some

. The question is, What steps are being taken to protect civilians in the event of a chemical war?

Observations

In April 1982, IDA was asked by the Office of the Under Secretary of Defense to address some of the questions we have raised about the comparative analysis of alternatives and the relative merit of chemical and nonchemical munitions in achieving military objectives. IDA's study will seek to answer three questions: What tactical uses might specific chemical weapons have on the battlefield? How effective are chemical weapons in attacking specific battlefield targets? What are the best mixtures of conventional and chemical weapons for attaining specific battlefield objectives? It will also evaluate chemical delivery systems. That DOD requested the study shows that it recognizes some of the important knowledge gaps we have identified. However, the study will not address the issue of tactical nuclear warfare.

Summary

Alternatives to the immediate production of binary weapons exist, but we find few studies that attempt to determine their relative merits in chemical war or what the results of adopting them would be. The principal analytic source is the JCS-sponsored study by IDA (Kerlin, 1981),

. We are left with the question of whether further investigation of this alternative is possible. Other questions that also remain would tell us about the ideal mixture of chemical and nonchemical munitions--their quantity, type, and effectiveness--and the protective measures that civilians would require in a chemical war.

DO BINARIES HAVE SUBSTANTIAL ADVANTAGES OVER UNITARIES?

The procurement of binary chemical weapons is an important topic in the current debate on chemical warfare. In 1980, the Congress authorized funds for the construction of a facility to produce binaries at Pine Bluff, Arkansas, and in 1981 more funds were approved for equipping it. The Administration is now seeking funds to start the production of these weapons. DOD's plans include a 5-year production program that would bring the U.S. stockpile closer to JCS requirements by complementing the usable and repairable unitary weapons with new binary weapons in the belief that binaries are more advantageous than unitaries.

DOD's requesting funds to produce and procure a newer version of a weapon, the binary, to complement and replace stocks of an older version, the unitary, is normal practice for maintaining a military position. Research, development, testing, and evaluation generate information that makes it possible to determine whether a new version of a weapon offers important advantages over an old one. For the binary chemical weapon, these steps have been hampered by the 1969 ban on open-air testing, with the result that adequate test and evaluation data on binaries are not available. Simulants have been used in laboratory and field tests, but there is considerable controversy over the credibility of the information they have produced.

Our review indicates that the assertions that are made about the specific technical and operational characteristics of binaries--their dispersion patterns and toxicity levels, for example--are not securely supported by empirical evidence and, therefore, must be taken as possibly inaccurate. Since these characteristics are important in determining what advantages binaries have for achieving military objectives, it follows that assertions about the advantages of binaries are also possibly in error. The lack of performance data prohibits conclusions about the performance of binaries and unitaries. As for their design characteristics, there is consensus that binaries have safety features for handling, storing, and transporting them, but there are also many arguments about how much these features cost. Moreover, our review indicates that some of the design features of binaries make them potentially disadvantageous compared with unitaries.

We find that binaries and unitaries have been compared on two dimensions. One is their technical and operational characteristics. The other is the implication that the choice of one

weapon over the other has for chemical warfare capability. We begin this section on the technical and operational characteristics with the question of safety because this aspect of the binary weapon is discussed more extensively in the literature than any other.

Knowledge review

Technical and operational characteristics

Safety. All the books, reports, and articles we reviewed agree that the binary weapons that DOD proposes offer safety in producing, handling, storing, and transporting them that the unitary weapons do not. This is because the individual components of a binary weapon can be kept separate until the time the weapon is to be used and, therefore, the danger of an accident is not as great as with a unitary weapon. Some argue, however, that the safety aspects have been overstated, and we found references to relative dangers. Ember (1980) indicates that the unitary weapons have an excellent safety record of several decades. Robinson claims that the chemical agents that are used to produce binary weapons are less deadly than nerve agents but dangerous substances nonetheless (SIPRI, 1975). He indicates that DF, one of the chemical agents used in binaries, is by itself chemically classifiable as "extremely toxic as an oral poison."

A 1981 study by the Department of the Army entitled "Programmatic Environmental Impact Statement: Binary Chemical Munition Program" suggests that there are potential safety problems in the production of binary chemicals. Binary VX-2, used for the Bigeye bomb, is formed from the reaction of substance QL and elemental sulfur. The study notes that changes in air quality caused by coal-fired boiler plants at the Pine Bluff Arsenal are associated with the interaction of airborne QL and sulfur dioxide emitted in coal combustion. A waiver is being sought that would permit the use of natural gas and fuel oil in the boilers. It is not clear whether other coal-fired boiler plants are in the region and whether they would affect the binary munition plant. The study points out that it is highly unlikely that QL can be procured from commercial sources because of specific corporate concerns with the problems in adapting existing facilities, in disposing of waste, and in QL reacting with sulfur.

Despite this information, the Department of the Army concludes, in its assessment of the 155-mm M687 GB-2 binary production facility at Pine Bluff Arsenal, that "the potential environmental impacts of the proposed Pine Bluff facility are judged to be insignificant" (Department of the Army, 1981, p. iii).

Other sources point out that the safety of binaries in handling, storing, and transporting them changes when it becomes

necessary to prepare for using them. As Robinson describes it, for example, preparing each binary artillery shell involves bringing one of two canisters from its storage place and putting it into a shell in which the other canister has already been placed (SIPRI, 1975). Mixing is relatively simple. Once the shell has been loaded into the howitzer and fired, the initial thrust is sufficient to rupture the diaphragms separating the two canisters, and the spin imparted to the projectile as it travels through the cannon's barrel at about 15,000 revolutions per minute automatically mixes the two chemicals, creating a nerve gas. Robinson reports that 10 seconds of mixing yields chemical agent at least 70 percent pure GB. Even though the mixing of the two components takes place only during and after firing, some sources claim that a shell containing both chemical components presents a number of associated dangers. For example, Meselson (1982) argues that the decision to prepare for use comes only under battle conditions but this means there is greater danger for the individuals who must assemble the binary weapons on the battlefield than for individuals using unitary artillery shells on the battlefield. We found no studies that have attempted to investigate this issue.

The question of the Bigeye bomb, the only air-delivered binary weapon that generates a persistent nerve agent, is even more complex. As with the artillery projectiles, the weapon's components--the liquid-filled weapon and solid-loaded ballonet (the compartment used to control the bomb's rate of descent)--are shipped and stored separately. Unlike the artillery round, however, the bomb is dropped, not fired, and the mixing is therefore different. Before a strike mission, the two chemical components are assembled in the weapon but separated by a 0.2-inch diaphragm. Then, at a selected point in the target area, the pilot activates the weapon and it proceeds through an automatic mixing sequence in which a cartridge within the ballonet fires, expanding the ballonet into a cylindrical form and violently propelling solid chemical agent into the liquid chemical agent, after which a gas-driven motor rotates the central tube, which is attached with perforated mixer blades, to start the mixing that completes the process. Approximately 10 to 15 seconds of mixing is required to completely generate the VX agent. After the release of the armed weapon, the fuse causes the shaped charge to cut through preformed points in the weapon skin, which allows the liquid to stream from the weapon. The liquid is broken up by the airstream as the bomb descends, creating droplets that fall to the target area. According to the Navy, 191 pounds of liquid agent can be dispersed in approximately 1 to 2 seconds.

This rather complex technical procedure in the binary Bigeye bomb, compared with the simpler unitary bombs such as the Weteye, suggests that the safety advantages of binaries introduce technical and operational uncertainties that, in turn, may have safety implications. For example, the Navy's development specifications indicate that, once mixed, the Bigeye must be

safe to carry for one hour. The question then is, If for any reason the bombing mission has to be aborted (as in intense enemy air defense), what happens? If the bombs are not released over enemy ground, the pilot may be faced with flying over or landing on friendly soil with "live" chemical weapons, some of which may be leaking. That this may be a problem with the binary bomb does not appear in the literature that we reviewed.

In summary, we find consensus that binary chemical weapons have subtantial peacetime advantages over unitaries in terms of safety, especially with regard to ease in handling and transporting them and in reducing the risk of accident. The unitary weapons have, however, enjoyed a long history of few incidents causing alarm about their safety. When the binary weapons are armed, they closely resemble unitary weapons in being "live" chemical weapons, and their safety diminishes thereafter. Furthermore, some of their peacetime safety advantages can become hindrances in wartime. These disadvantages, however, are still conjectural, and their investigation seems warranted.

Mixing requirements. The mixing time required for transforming the binary's two chemical components into a chemical weapon seems to imply some particular operational problems not encountered by users of unitary chemical weapons, but we found no literature that even raises the issue. For example, with the artillery projectile, mixing is induced upon firing and continues until impact. Laboratory tests indicate that the minimum mixing time to achieve 70 percent purity is about 10 seconds. With the Bigeye bomb, mixing is initiated before the bomb is dropped. The technical performance goal is to achieve 70 percent purity after 15 seconds and greater than 75 percent purity after 220 seconds of mixing. These differences in time seem to imply different operational problems for the weapons' users.

For the artillery shell, the 10-second mixing requirement after firing logically suggests that an artillery unit cannot engage any target located closer than 10 seconds of flight time away. With the usual firing procedures--firing at less than a 45-degree elevation--the question is whether military units can engage targets closer than 5 kilometers away. We found no source that even raises this question.

For the Bigeye bomb, the mixing that is initiated before the bomb is dropped seems to create a different problem. There is no similar range constraint. However, once mixing has started, the lethality of the chemicals is greatest early in the mixing cycle and decreases the longer the agent is held in the weapon. Thus, the aircraft pilot seems subject to several operational constraints not present with the use of a unitary chemical bomb like the Weteye. That is, the pilot must first decide when to initiate the mixing sequence and must then act from the knowledge that the performance of the weapon depends on time. The question is whether or not a pilot waiting too long to initiate mixing will miss the target, or make only a weak

attack, or initiating the mixing too early will diminish the attack's effectiveness. These questions seem logical and are implied by the weapons' characteristics, but we found no source that raises them or discusses the issues created by them.

Weight and volume. Another technical characteristic of the binary weapons that figures prominently in the safety discussion is that the two canisters, both containing a chemical agent, are kept separate until they are used. This has been identified as a peacetime safety advantage, but it is also said to pose disadvantages of weight and volume that affect operations (Meselson, 1982). The Army data we present in table 10 do not support the argument that binaries pose greater problems than unitaries because of substantially increased weight requirements.

Available evidence does, however, support the argument that the need to keep one canister separate from its main shell, into which it will eventually be placed, substantially increases the

Table 10

A Comparison of Unitary and Binary Munitions by Weight and Volume

Munition type	Weight (lb)	Volume (cu ft)
155-mm artillery projectile		
Unitary M-121 96 rounds, 12 pallets	9,984	79
Binary M-687 96 rounds, 12 pallets	8,940	251
Binary M-687 96 canisters[a]	781	42
Ratio of binary to unitary	1.0	3.7
8-in artillery projectile		
Unitary M-426 90 rounds, 15 pallets	18,825	186
Binary XM-736 90 rounds, 15 pallets	19,050	316
Binary XM-736 90 canisters[a]	2,000	52
Ratio of binary to unitary	1.1	2.0
Bomb		
Weteye 2 rounds	1,702	52
Bigeye 2 rounds	1,702	64
Bigeye 2 canisters[a]	149	9
Ratio of binary to unitary	1.1	1.4

SOURCE: E. P. Kerlin, A. J. Rolfe, and J. E. Shafer, Chemical Warfare in Central Europe, Circa 1986, SECRET (Arlington, Va.: Institute for Defense Analyses for the Organization of the Joint Chiefs of Staff, December 1981).

[a]A canister contains one of the two chemicals for the binary weapon.

requirements for storage space and transportation. As we show in table 10, Army estimates indicate that nearly four times the space is required for transporting and storing binary munitions, compared to unitaries. Thus, it is possible that simply finding the additional storage space that the parts of the binary weapon require (even if there is no increase in the total number of weapons) could present a logistics problem.

The data on volume raise questions about deployment also. For example, it seems logical that there would be less space in carriers for other weapons, equipment, and supplies when binaries rather than unitaries were being transported. We raised a similar question before (GAO, 1977), but we do not find that it has been answered. Others have asked related questions from the premise that, given volume requirements and safety considerations, the two binary canisters might be transported by different vehicles and stored in separate locations, rendering one shipment useless if the other were lost (Roland, 1982). The success of transportation missions thus seems to have at least two risks.

Sound and odor. Artillery shells containing chemical agents potentially emit sound and odor. Examining sources that compare binary and unitary weapons for these characteristics, we found that only a few discuss them. Meselson (1981) and Robinson (SIPRI, 1975) indicate that the unitary chemical-filled artillery shells are virtually odorless upon impact and that the projectile makes no distinct noise. They add, however, that a burster charge required in the binary weapon does make a distinct noise that detracts from any advantage of surprise in its use. Meselson (1981) also indicates that the production of nerve gases may be accompanied by byproducts with specific odors. For example, the VX binaries are said to produce a strong odor of sulfur because polysulfide is one of their components.

The argument is that such sounds and odors might warn enemy troops, giving them time to take protective measures. What are the chances that by the time one heard a binary projectile coming, or smelled the distinctive odor of a binary weapon, it would be too late for protective gear? We found no data of any kind demonstrating that this question has been investigated. It is not raised in the DOD-related literature that we examined.

Other characteristics. Binary and unitary 155-mm artillery shells could be compared and contrasted for toxicity, dispersion patterns, and area of coverage upon impact. However, such analyses have not been made from data on performance, because of the 1969 ban on testing chemical weapons. In 1977, we reported that a few tests were made with binaries just before the ban (GAO, 1977), but Robinson (SIPRI, 1975) pointed out that chemical agents are modified over the years, so that test results from before 1969 would not be valid for today.

What has been designed and developed since the ban is an extensive program of testing simulants in the laboratory, with the aim of determining what the operational characteristics of binaries are. Estimates are made about toxicity, dispersion patterns, and areas of coverage with nonlethal chemical simulants instead of binary munitions. (The gaming simulations undertaken by IDA (Kerlin, 1980, 1981) were probably based on simulant data.) Critics of the results of testing with simulants say they are inadequate substitutes for open-air test results, asserting that the obstacles to developing appropriate simulants are insurmountable. For example, Robinson states that simulants must be made of materials of low toxicity that resemble the binary components they are simulating in their physical properties and in their reactions, both kinetically and thermodynamically, and that interact to form a product of low toxicity as a vapor, an aerosol, or a spray that resembles the binary product being simulated (SIPRI, 1975). He concludes that these are virtually impossible objectives. This may be an overstatement, but it is nonetheless true that the confidence one can have in findings from simulants is related directly to the ability to achieve these objectives.

We found evidence even within the military that the reliability and validity of simulant data are questionable. For example, in the Test and Evaluation Master Plan of the Bigeye Weapon System (BLU-80/3), the Naval Air Systems Command has indicated recently that a critical issue for the Bigeye bomb continues to be whether its operational effectiveness can be determined in terms of downwind travel and diversity of concentrations. The question reflects the Command's understanding that binary VX and conventional VX have different physical properties and that all binary dispersal testing has been with simulants. Production of a weapon is rarely begun without field tests and the evaluation of prototypes, however.

Implications for achieving military objectives

Any attempt to compare binaries with unitaries in terms of their ability to help achieve military objectives is constrained by the lack of knowledge about the technical and operational characteristics of binaries. If casualties, for example, are the objective, it is reasonable to assume that both weapons would have an effect under similar conditions. However, it is difficult to determine the difference in their effects and even the direction of the difference--that is, to determine the one that can cause more casualties with the same number of shells. Robinson states that no greater efficiency whatsoever can be seen for binaries in producing enemy casualties (SIPRI, 1975). He conjectures that binaries would in fact be inferior, basing this on the claims that a greater volume of binary munitions is needed to produce a given effect, that binary performance is less predictable and therefore less controllable than unitary performance, and that the number of tactical situations in which

binaries can be used is smaller. His logic seems reasonable. For example, since mixing requirements put time and, therefore, range constraints on the use of artillery, the number of tactical situations in which binaries could be used might be reduced. Also, since there is evidence that the binary payload includes nontoxic byproducts, binaries might produce fewer lethal doses of poison than corresponding unitaries. Nevertheless, the counterargument is that these are not limitations in reality. Analysis through simulation shows only that casualties increase as the quantity of chemical munitions increases

(Kerlin, 1981). The analysis does not allow a determination of whether the change in munitions is instrumental in the increase in casualties. We found no other analyses.

Observations

In this section, we have discussed the information that is available for determining whether or not binary weapons have substantial technical and operational advantages over unitary weapons and whether the binary weapons are the better aid in achieving military objectives. Some of it argues that unitary chemical weapons are unpredictable in scale and in duration of effect and, therefore, of limited military use. Experts on how the environment affects the use of chemical weapons--wind, topography, temperature, humidity, the general state of the atmosphere--state that, for example, local surface winds in the air layer nearest the ground and up to 300 meters are frequent and widespread in mountain ranges and near sea coasts. As slope breezes, valley breezes, and land breezes, local surface winds could shift a toxic cloud in directions that could not be predicted from a study of the general meteorology of an area. The example suggests that our comparison of binary and unitary chemical weapons is based on inadequate data, even for the unitary weapons. Additionally, the variables that govern the performance of chemical weapons may be, as shown in the example, too situation-specific for credible analysis.

Summary

In our search for information from which it might be determined whether binary weapons are substantially more advantageous than unitary weapons, we found that a lack of field-test data leaves a substantial gap in what is known about binary weapons. Moreover, the credibility of data from simulations has been challenged. Some literature even questions the existing technical and operational knowledge about unitary weapons.

The sources generally agree that binaries have features that make them safer to handle and transport in peacetime and less vulnerable to serious accident. However, we find reasonable discussions indicating that some of these peacetime safety advantages could become safety hindrances in wartime. The mixing requirements of the binaries may diminish their operational

effectiveness, but we found no sources that discuss this possibility. Available evidence does, however, support the argument that binaries place greater space requirements on storage, transportation, and deployment.

The available data do not sustain the argument that binaries offer substantial technical and operational advantages over existing weapons. We raised many specific questions in this section. Those that concern the general lack of data on binary weapons are especially critical:

--What steps, if any, can reasonably be taken to provide empirical data on the operational and technical characteristics of the binary weapons?

--If better information cannot be accumulated, how serious is the risk that the United States may be replacing present weapons with inferior ones? What effect could this have on the U.S. modernization program?

--Should the production decision about binaries be delayed until more is known about the performance capabilities of binary weapons?

--Without resorting to open-air testing, what means do we have for reducing the uncertainties about the operational effectiveness of the binary weapons?

SUMMARY AND CONCLUSIONS

In this chapter, we have discussed three aspects of chemical warfare modernization: the factors in modernization, the alternative ways of modernizing, and the advantages of binary chemical weapons over unitary ones. Our review indicates that any attempt to modernize the U.S. chemical warfare capability must carefully consider and integrate a variety of factors in addition to the weapons. We find that DOD's modernization program identifies the major factors that have to be considered, but we find little evidence that DOD's modernization efforts have considered the factors in a way that is comprehensive or integrated. We have raised many specific questions that should be answered.

The literature describes alternatives to the production of binary chemical weapons, but few studies have attempted to determine the possible results of using the several alternatives in the event of a chemical war or to determine their relative merits.

. However, further investigation of this policy option is necessary. Additionally, information gaps leave open questions about the best mixture of chemical and

nonchemical munitions, in terms of both quantity and type, about the effectiveness of chemical warfare for producing casualties, and about protective measures for civilians.

As for whether binary chemical weapons are more advantageous than unitary chemical weapons, we found that the lack of field-test data leaves a wide knowledge gap. Some evidence supports those who argue that binary weapons mean greater space requirements for storage and transportation--a disadvantage. Consensus agrees that the design of binary weapons gives them safety features for handling and transportation in peacetime--an advantage. However, we found that this peacetime advantage may have related wartime costs. There is also some question about safety in the production of binary chemicals. More investigation is needed.

We conclude that modernizing a chemical warfare system requires the following: (1) adequate information on what the alternatives are, (2) a strong reason based on credible data for selecting one alternative over another, and (3) comprehensive and integrated plans to improve capability with regard to doctrine, stockpile, delivery systems, defensive equipment, training, and other factors such as these. Our review of existing information on the U.S. modernization program does not reveal convincing evidence that these three requirements have been adequately met.

CHAPTER 5

HOW DOES MODERNIZATION AFFECT THE PROSPECTS FOR DISARMAMENT?

Disarmament is the ultimate deterrent. By signing a comprehensive chemical weapons ban, nations agree to give up their means of waging chemical warfare and publicly avow that they have no will to fight in a chemical war. In this chapter, we report on our investigation of what is known about how modernization of the U.S. chemical warfare capability might affect prospects for disarmament. Our investigation included an examination of the current status of chemical warfare disarmament negotiations and an exploration of problems that still prevent reaching a ban on chemical weapons.

For more than 10 years, the Conference of the Committee on Disarmament, representing 40 nations, discussed an agreement that would ban all chemical weapons. Since 1979, the Conference has been known as the Committee on Disarmament. In most of those years, verification issues were a great stumbling block in negotiations. We found many speculative forecasts but little analysis of how modernizing through the binary program might affect prospects for disarmament. Two important questions still require comprehensive answers. How easy are binaries to produce and what would their effect on proliferation be? How and to what extent would binary production resolve or complicate existing verification problems? Among the large number of

QUESTION	SUBQUESTION
1.0 How is chemical warfare deterred?	1.1 What is a credible deterrence capability? 1.2 What are the different ways of deterring chemical warfare? 1.3 How has the United States chosen to pursue deterrence?
2.0 How do the United States and the Soviet Union compare in chemical warfare capability?	2.1 What are the U.S. and Soviet doctrines governing the use of chemical weapons? 2.2 How does the U.S. chemical stockpile compare with the Soviet Union's and how is stockpile need determined? 2.3 How do the U.S. and Soviet chemical warfare delivery systems compare? 2.4 How do the United States and the Soviet Union compare in defensive equipment and personnel? 2.5 How and to what extent have the United States and the Soviet Union prepared for implementation?
3.0 How can the United States modernize its chemical warfare system?	3.1 What factors are necessary for modernization? 3.2 What are the alternatives to binaries? 3.3 Do binaries have substantial advantages over unitaries?
4.0 How does modernization affect the prospects for disarmament?	4.1 How successful have chemical warfare disarmament efforts been? 4.2 What are the verification problems in banning chemical weapons? 4.3 What implications does modernization have for disarmament?

sources we reviewed on disarmament issues, most are historical reviews, opinions, and issue reviews or analyses.

HOW SUCCESSFUL HAVE CHEMICAL WARFARE DISARMAMENT EFFORTS BEEN?

In our review of the historical documents, we found that progress in chemical warfare disarmament negotiations has been slow and difficult. It is not only that verification issues have been and remain a difficulty in the negotiations. It is also that new charges that the Soviet Union and its allies have used chemical weapons and toxins (or biologically produced chemical poisons) have been reported, leading the U.S. Administration to doubt the value of direct negotiations with the Soviets.

SIPRI (1971) reports that great hopes were set on disarmament and general international cooperation after World War I. Those hopes were not completely realized, even though they did see some fruition in the 1925 Geneva Protocol, which outlawed the use of chemical and biological weapons. While the United States did not ratify the Protocol until 1975, enough nations did ratify it in its early years that it entered into effect in 1928. One might ask, Since there is a treaty, why is another needed?

The Geneva Protocol places no restrictions on developing, producing, or stockpiling chemical warfare agents. It declares only that the use of chemical weapons in war is prohibited. Given that most nations signing the treaty reserved the right to use chemical weapons against other countries resorting to them first, it is essentially a "no first use" agreement. Further, some nations, including the Soviet Union but not the United States, believe themselves bound by the treaty only in relation to its other signatories. What is being sought in addition is a treaty that will ban--without exception--the development, production, and stockpiling of chemical warfare agents and, thereby, all use of chemical weapons.

In 1969, the Conference of the Committee on Disarmament began seriously considering a ban on biological and chemical weapons. The Soviets supported an essentially unverified ban of both biological and chemical weapons, while the United States and the United Kingdom considered it critical to be able to verify that chemical warfare agents are not being produced. The debate was effectively postponed when a treaty was proposed for biological disarmament only. The United States argued that chemical warfare and biological warfare should not be linked. According to the Stanford Arms Control Group, the Western powers were willing to accept the risk of clandestine evasion of a biological warfare treaty in order to forestall a biological weapons technology race that could also lead to the spreading of such weapons (Barton and Weiler, 1976). Biological weapons had not proved their significance in warfare; it was thought

difficult to insure that biological weapons would reliably cause immediate damage to a target and that they would not spread beyond control. According to Goldblat, agreement could be reached because of the uncontrollability, unpredictability, and therefore limited military use of biological weapons (Carlton and Schaerf, 1975).

The outcome was the 1972 Biological Warfare Treaty, which prohibits the producton and stockpiling of biological warfare materials. It contains no provisions for the verification of compliance. The nations that signed the treaty, however, committed themselves to continuing negotiations toward a chemical weapons ban. As signatories of the treaty, both the United States and the Soviet Union are so committed. Between 1976 and 1980, they held bilateral talks in Geneva on chemical weapons disarmament, expecting to present any basic text they could agree on to the multilateral Committee on Disarmament for elaboration into a multilateral chemical warfare treaty.

Verification issues have been a great stumbling block all along, as they were in the twelfth and most recent round of bilateral discussions in July 1980. Talks would have resumed in January 1981 but the U.S. Administration wanted time to review the status of all disarmament negotiations. According to the Arms Control and Disarmament Agency (ACDA), the bilateral talks would be scheduled quickly if the United States thought that they would be productive but it is waiting for some sign of flexibility in the Soviet bloc. Meanwhile, the Committee on Disarmament established a Chemical Weapons Working Group, which has been meeting during the Committee's semi-annual sessions since 1980. These talks also remain stalled on verification issues, however.

The United States has alleged that the Soviet Union and its allies have used chemical and toxin weapons in Afghanistan, Kampuchea, and Laos, and this compounds the problem. According to Hoeber (1981), if it is valid that signatories of the Geneva Protocol are bound by the treaty only in relation to its other signatories, then the use of chemical warfare in these three countries would violate only the spirit of the Geneva Protocol, not its letter, since they did not sign the Protocol. In any event, the allegations have raised serious doubts in the U.S. Administration about the value of continuing bilateral negotiation on chemical weapons disarmament. As the U.S. Department of State indicated in July 1982, bilateral negotiations have not been resumed

> "because there is little prospect for productive negotiations under existing circumstances. Should the Soviets demonstrate a willingness to accept genuinely effective verification and compliance arrangements, and should they demonstrate a willingness to abide by existing international obligations on chemical,

)biological and toxin weapons, the prospect for serious bilateral work would be enhanced." (United States, House, 1982, pp. 4-5)

Examining the issue of a Soviet use of chemical and toxin weapons in Afghanistan and Southeast Asia is beyond the scope of this report, however.

In June 1982, at the United Nations Special Session on Disarmament, Soviet Foreign Minister Gromyko presented a draft paper containing updated Soviet views on chemical weapons arms control. The draft is of particular interest in that it suggests the possibility of a shift in the Soviet position on verification. The U.S. Department of State indicates that it is too early to determine whether the shift is propaganda or a genuine breakthrough. Some voices (Robinson, 1982, for example) argue, however, that the paper presents compelling reason for resuming bilateral negotiations, since bargaining will not proceed rapidly in the full forum of 40 delegations represented in the Committee on Disarmament.

WHAT ARE THE VERIFICATION PROBLEMS IN BANNING CHEMICAL WEAPONS?

The United States and the Soviet Union have consistently and adamantly adhered for 10 years to opposite positions on mandatory on-site inspections. The Soviet Union has argued that national technical verification--that is, self-inspection--suffices, although it agreed in 1980 to optional inspection by challenge. The United States argues that systematic international on-site inspections are mandatory. It is only recently that the Soviets have hinted that there might be flexibility in their position.

Under national verification procedures, as SIPRI discussed them in 1980 (SIPRI, 1980b), each government would develop its own system for insuring the effective implementation of a chemical weapons ban. This might include the establishment of national control committees made up of representatives of the government, the press, trade unions, scientific and public organizations, and prominent scholars and scientists. The committees would develop a program for testing and verifying compliance in their country. According to SIPRI in 1980, national verification is also usually understood to mean that each government would allow photoreconnaissance satellites or other extraterritorial sensors to monitor treaty compliance.

While stating that national technical verification is important, the United States argues that this by itself is not sufficient. According to this argument, each nation must witness the others' destruction of stockpiles and dismantling of production facilities in order to verify compliance. Also necessary is the right to make on-site inspection in order to

investigate suspected violations, such as the presence of stockpiles that are hidden and undeclared or declared but undestroyed, and the operation of chemical weapons production facilities that were by agreement to be closed down and destroyed.

By July 1980, the United States and the Soviet Union had agreed that verification should be based on a combination of national and international measures. They agreed that international verification should include the creation of a consultative committee, although the specific functions of this committee were not agreed on. They agreed on the right to challenge when suspicions arise, the right to request relevant information on the actual state of affairs, and the right to request on-site investigation. They agreed that requests could be honored or, with explanation, denied. It has been pointed out that the Soviets have never permitted actual verification on Soviet territory of any arms control agreement. The Arms Control Disarmament Agency told us that no agreement on verification has ever been reached by these groups and that, while progress has been made, the sides remain far apart on critical issues.[1]

The draft paper delivered by Foreign Minister Gromyko on June 15, 1982, refers to the possibility of carrying out systematic international on-site inspection of the destruction of stockpiles and of permitting the small-scale production of supertoxic lethal chemicals. ACDA believes, however, that the Soviets should expand upon and explain what is meant by the new language (United States, House, 1982). One issue is what the Soviets mean by the term "systematic." According to Robinson (1982), it has come to mean "routine and mandatory," not challenge or ad hoc or optional, in the parlance of chemical weapons negotiations, but it is not clear in what sense the Soviets have used the word. While some view the Soviet draft paper with cautious optimism and as giving reason to resume the bilateral negotiations, ACDA has taken a "wait and see" position, believing that serious problems remain on the verification issues.

Knowledge review

The literature contains a wealth of documents that are essentially reviews or analyses of disarmament issues, including verification. Lundin (1979), for example, reviewed and suggested possible solutions for such problems as the fear that, with on-site inspection, chemical plants will be visited routinely, jeopardizing patents and commercial secrets. Meselson

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[1]A private and informal group of scientists from twenty countries, known as the Pugwash Chemical Warfare Study Group, has been meeting since 1974 on technical problems related to chemical weapons disarmament. While its members may agree, its agreements do not have the formal backing of any government.

and Robinson (1980) reviewed the status of bilateral talks and discussed the utility of chemical weapons, concluding that only arms-limitation will permanently remove the threat of chemical warfare and that without arms-limitation the arms race will continue, each side always trying to catch up to or surpass the others. SIPRI (1973) discussed verification issues and delineated the problems that arise with specifying in detail exactly how a national agency could exercise control over activities for which it has responsibility. All such problems are viewed in the literature as areas requiring close study that they have, for the most part, not received.

We did not find many research studies on compliance verification. We were especially interested in studies on the effectiveness of nonintrusive surveillance techniques. Various authors such as Goldblat and Moch (Carlton and Schaerf, 1975), Lundin (1979), and SIPRI (1973, 1979, 1980b) have suggested that their use would increase the possibility of verification. We wanted to identify studies that have determined the extent to which such techniques contribute to verification.

In 1970, the Midwest Research Institute issued a major study on the topic for ACDA. It examined the inspection and verification of the ability to produce, transport, and store organophosphorus nerve agent in four countries representing a middle range in economic and technological achievement. Each country was analyzed systematically in terms of its immediate and deferred chemical munitions production capabilities, its ability to apply evasive tactics in chemical weapons development, and the time required for detecting treaty violations in each country. Among the elements of nonintrusive techniques that were studied was the analysis of published research reports and budget and financial records, surveillance data on imports and exports related to chemical weapons, information on defense-related activity such as training, records of the activities of professional personnel and international construction companies, information recorded by sensors in remote air or space platforms, and knowledge volunteered by citizens and foreigners in the countries.

For the most part, the Midwest Research Institute did not describe the methods it used to gather data, but the findings convincingly support the conclusion that the overall probability of detecting chemical warfare activities by nonintrusive means alone is low. According to the study, the difficulty of detection varies significantly with the cooperation given by a nation that is suspected of noncompliance, any delays in the investigation, and the type of violation that is being alleged. For example, it is pointed out in the study that

--the prospects appear to be fairly good that declared agent plants could be monitored from a nonintrusive, remote inspection platform with infrared sensors;

--the probability is low that undeclared chemical weapons facilities could be detected with remote sensors because the effectiveness of sensors varies inversely with the distance between the sensing platform and the target site, which in turn is because the sensing equipment has limitations, the environment affects it, and nations may use evasive tactics such as camouflaging a plant that produces chemical weapons as one that produces chemicals for commercial purposes;

--research programs supporting chemical warfare are difficult to identify with nonintrusive techniques because it is difficult to separate offensive chemical warfare research work from defensive and commercial efforts when the same toxicological study can pertain to both chemical warfare and the cosmetic and pharmaceutical industries;

--nonintrusive measures do not easily identify chemical weapons development programs because the equipment and facilities needed for development studies are relatively small and easy to conceal, making it necessary to conduct on-site inspection of raw materials, process samples, wastes, and the like.

Additionally, the Midwest Research Institute found that large nations can easily conceal budget and economic activities related to chemical warfare, reducing the value of nonintrusive techniques. Similarly, imports of materials necessary for building a chemical warfare capability are difficult to verify.

The recent charges that the Soviets have used chemicals in war in Southeast Asia and Afghanistan support the conclusion of the Midwest Research Institute that the probability of detection by nonintrusive means alone is low. According to the U.S. Department of State (Haig, 1982), the United Nations initiated an international investigation of the use of chemical weapons, but in June 1982 the investigating team had still been denied admission to the three countries in which the use of weapons has been alleged. The team's findings were inconclusive, partly because of the countries' refusal to cooperate.

The Midwest Research Institute study can be criticized on the grounds that it looked at the inspection techniques separately rather than in combination. Meselson and Robinson (1980) and SIPRI (1971-75, vol. 5) argue, for example, that verification does not have to be anything like 100 percent efficient to be effective. What is required is simply a sufficiently high probability of detection to provide deterrence on one side and reassurance on the other. Small research and development effort is not critical, but there must be a high probability of detecting chemical warfare preparations whose scale is large enough to constitute a major military threat. The relatively

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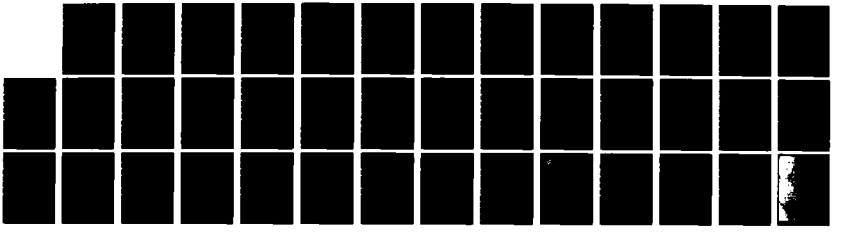

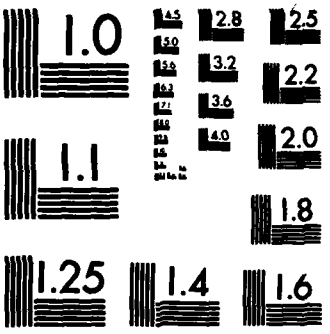

high probability of detecting the large-scale efforts comes, it is argued, from using multiple verification techniques.

SIPRI advances the argument that using several techniques of verification makes the chance of detecting an infraction substantial, even though the probability of detection with any one of the techniques may be low (1971-75, vol. 5). SIPRI offered as an example a case in which there are three techniques, each with a 20 percent probability of detection. Over all, the probability of avoiding detection is only about 50 percent. What studies support or refute this contention?

We found only one source of direct relevance. Roberts and Romine (SIPRI, 1975), on the staff of the Midwest Research Institute, examined the potential of a combination of techniques for verifying the destruction of stockpiles. The techniques included on-site inspection and the analysis of interlocking records on production, transportation, storage and stockpile, imports and exports consumption, and destruction. On-site inspectors would be used to verify the quantity and type of agent destroyed. Records analysis would determine what and how much agent had been stockpiled when the agreement went into effect. Roberts and Romine did not actually conduct or even simulate an analysis, but they reasoned logically and their conclusions seem sound. They indicate that the probability of evasion can be controlled with these techniques but that this approach to verification could involve a massive intrusion on a nation's records system, depending on the level of confidence needed and the point in time at which the stockpile is verified. Also, it is potentially very costly to process such records, even were access to them permitted. The unanswered question is whether techniques or combinations of techniques that lessen the probability of evasion are always highly intrusive.

Observations

Our review leads to three observations on verification issues. First, the research information on sensors, space platforms, and other "spy in the sky" satellites is not up-to-date. The Midwest Research Institute report was issued in 1970, leaving us with the question of the extent to which technological improvements in the past 12 years have increased the effectiveness of the type of surveillance it discusses. For example, the Midwest Research Institute report mentions what were in 1970 up-and-coming sensing techniques--long-path infrared monitoring systems and lasers. Similarly, research in nuclear arms control may prove applicable to chemical arms issues. For example, RECOVER, a communications system for "REmote COntinual VERification" of international nuclear safeguard sensors, has been developed to provide the International Atomic Energy Agency with the ability to monitor continuously from agency headquarters safeguard devices that have been deployed at nuclear facilities worldwide. RECOVER's benefits for international nuclear safeguards are not certain, and questions have been raised about its

cost-effectiveness. Still, the use of a RECOVER-like system to verify arms control agreements on chemical weapons production has begun to gain attention through discussion in international forums. In 1981, ACDA proposed that the Committee on Disarmament consider the possibility of using RECOVER to monitor instruments that might be used to verify compliance with a treaty banning chemical weapons production. A March 1982 meeting of the Committee proposed that an international technical study be conducted to identify chemical weapons verification problems amenable to solution by a RECOVER-like system. One such solution might be to monitor inactive chemical weapons production plants to verify their inactivity. A RECOVER system could help close the gap between on-site verification and none at all. ACDA has indicated that RECOVER's techniques might aid chemical weapons verification, but it has also indicated that a RECOVER system for chemical weapons would probably be only one part of a network of complementary and overlapping verification methods. An update on the status of these and similar techniques for the surveillance of chemical warfare activities is needed.

Second, computer technology seemed to be the hope of the 1970's for solving on-site verification because of the computer's ability to collect and analyze masses of data (Carlton and Schaerf, 1975). However, the only analysis pertinent to this view that we have seen is in an article by Roberts and Romine (SIPRI, 1975). They do not mention computers, but they suggest that analyzing interlocked records in combination with some on-site verification can verify stockpile destruction with a high probability of detecting evasion but that the analysis itself might require a massive records intrusion. Thus, it seems that computer verification may well be an intrusive technique. It is evident that more study of this issue is necessary.

Third, the assertion of SIPRI and others that using several techniques at once greatly increases the probability of detecting an infraction is attractive, but it has problems that stem from lack of knowledge. The argument assumes that we can calculate an index of the likelihood of avoiding detection for every nonintrusive technique, an index that would take into account factors such as ease and cost of evasion. However, the fact is that we do not now have measures of either the intrusiveness of the different techniques or the ease with which they could be evaded. Even rough estimates would be helpful. If the probabilities of detection with nonintrusive techniques are all very low in the first place, the cumulative result is not reassuring. What may be needed is an identification of the techniques that are the most difficult and costly to evade while being least intrusive.

In summary, the obstacles to an agreement about verification for a chemical weapons treaty seem great without agreement on systematic or mandatory on-site inspection. What is needed is sound and up-to-date estimates of the probabilities of detecting different chemical warfare-related activities with

different surveillance techniques having different degrees of intrusiveness. There seem to be few current research activities aimed at putting these aspects of verification into focus.

WHAT IMPLICATIONS DOES MODERNIZATION HAVE FOR DISARMAMENT?

Statements about the likely effect of modernization on disarmament prospects, particularly those emphasizing the production of binary weapons, are judgmental and therefore open to debate. Opinion revolves around two issues. The first is whether modernization by the United States would precipitate a breakthrough in the disarmament negotiation stalemate or a breakdown of disarmament efforts and a concurrent arms race. The second is the extent to which producing binary weapons would lead to the proliferation of chemical weapons. Among the questions that have to be answered in order to resolve these issues, two are very important: How easy are binaries to make? How do binaries complicate the problem of verification?

Breakthrough or breakdown?

The proponents of modernization who argue for binary production say that the United States has been negotiating in Geneva from a position of weakness, given its deteriorated chemical warfare capability. The Soviets have a chemical warfare capability dwarfing that of the United States, so the argument runs, and thus have a strong bargaining position. Among others, Hoeber, as Principal Assistant Secretary for the Army's Research and Development Program, has expressed the belief that the Soviets have never participated in chemical disarmament negotiations in good faith:

> "From Soviet actions in the arms control arena, coupled with their military buildup and their attempts to influence Western disarmament, one can conclude that the Soviets' frequently expressed desire for a chemical warfare ban is purely a deception or a propaganda move whose objective is to frustrate U.S. efforts to redress the imbalance, thus prolonging the asymmetry in their own favor." (Hoeber, 1981, p. 51)

Some believe that the Soviets have prevented U.S. improvements in what they characterize as a deteriorating and deficient chemical capability merely by sitting down at the negotiating table. For example, Bay (1980) goes so far as to say that the Soviets have forced the United States into the position of unilateral disarmament for more than a decade.

From this position, there is little to be lost by a new policy featuring both arms control negotiations and chemical warfare improvements. Hoeber (1981) states that while the U.S. approach of negotiating from a position of restraint rather than one of strength has been based on good intentions and high

expectations, it is time to stop. There is no rational basis, she continues, for believing this approach will work any better in the future than it did in the past. Others argue, further, that improving the U.S. chemical weapons stockpile will effectively produce Soviet concessions on key negotiating issues such as on-site verification, making offensive capability a valuable bargaining chip.

Instead of a breakthrough, however, some expect a breakdown of disarmament talks if binaries are pursued. Arkin of the Center for Defense Information, for example, is cited as indicating that the U.S. production of chemical weapons would diminish arms control prospects (Ember, 1980). Robinson points out that the United States has not always been credited by its Committee on Disarmament colleagues with a positive attitude toward the negotiations--there have been charges that the United States has not responded constructively to draft conventions. He states that the United States' beginning a binary program would make it highly likely that the negotiations would collapse completely: "any notion that the binary program ought to be supported as a bargaining chip should be seen for what it would be: a deliberate attempt to obstruct the chemical negotiations" (Robinson, 1975, pp. 67-68).

Will modernization result in an arms race? Again, the sides line up. Holden (1982) quotes Hoeber as taking the position that whenever the United States builds up, the Soviets build up, and whenever the United States does not build up, the Soviets build up. Thus, she perceives the arms race issue as "totally fallacious." She also views history as indicating that the magnitude of Soviet military programs has by and large been unaffected by the magnitude of U.S. programs. Others, such as former Ambassador James Leonard, believe that the United States has gotten much credit for refraining from building binaries and that the Soviets are sure to respond with stepped up activities if the United States proceeds with binary production.

We know of no data base for evaluating these positions. Among the individual arguments, some seem to be more biased than others, but this does not make them invalid. A look at how U.S. buildups during negotiations affect other weapons could clarify the matter, if there have been a number of cases. While Hoeber uses history as an argument for defusing the arms race issue, she does not include any information that would support the argument positing favorable arms control outcomes as a result of modernization.

Will binaries increase the proliferation of chemical weapons and further complicate the disarmament negotiations?

Will binaries increase the proliferation of chemical weapons? Will they complicate the negotiations on disarmament? The answers depend on the ease with which binary chemical

weapons can be produced and on how binaries complicate the already difficult verification issue.

The arguments on binary production and the proliferation of chemical warfare are straightforward. In an undated report, the Association of the U.S. Army, a nonprofit educational association and staunch supporter of binaries, summed up the proponents' stance as saying that when a technology's time has come, it arrives. The technology is not and cannot be a U.S. secret, the argument continues, and can practically be bought at the newsstand by any nation that wants it.

On the other side, the Center for Defense Information (1980) represents the opponents' belief that the U.S. production of binary weapons will legitimize the technology and encourage its spreading to other countries. Other countries, the argument continues, will find a cheap and legal chemical weapons arsenal attractive for countering the threat of nuclear or chemical attack from neighbors or other nations farther away. They will follow the United States as a leader of technological fashion in the military, and the world will become more complicated and dangerous.

How easy are binaries to produce? We found no analytic studies examining the ability of countries to produce binary weapons that is similar to the Midwest Research Institute's 1970 study on unitaries. Various authors have discussed the issue. For example, the Center for Defense Information (1980), Lundin (1973), and the Stanford Arms Control Group (Barton and Weiler, 1976) indicate that producing binaries is much easier than producing other nerve agents in that it is not necessary to build and operate a complex chemical plant; weapons can be filled from commercial chemical sources. Because the binary elements are not toxic until they have been mixed together, it is believed that binary weapons could be handled by conventional industrial facilities.

Robinson (1975) explains that nerve gas has been available since 1950--the year in which detailed laboratory procedures for its preparation were first reported in specialist literature--but not really accessible given that producing it requires procedures on a large scale performed by skilled chemists in well-equipped labs. According to Robinson, binaries push the cutoff point for production capability down the scale because they do not require heavy investments of capital, skilled labor, and technological expertise. With binaries, Robinson states, access to nerve agents is as easy as access to domestic factories that produce pesticides or organophosphorus plasticizer. He explains that some industrial commodities are made of certain chemicals that can serve as nerve gas intermediates. One of these--ethylphosphonothioic dichloride--is produced, according to Robinson, in the United States for new pesticides in quantities exceeding a million pounds a year. While not a binary component itself, it is one very simple and safe chemical step short of

it. Robinson believes that much data from which design specifications can be drawn up are already available in the U.S. patent literature and that it is inevitable that, if the United States were to start binary production on a large scale, more data would become rapidly available.

According to Robinson (1975), DOD denies that binaries would foster proliferation. The DOD argument is that binary munitions are far more difficult to manufacture than present chemical munitions because combining the two nonlethal ingredients in a projectile in flight requires highly sophisticated technology.

In short, while the arguments are straightforward, the "true" picture is not clear. Binary agents may be relatively easy to produce, but binary munitions may be very difficult to manufacture. We found no research similar to the 1970 Midwest Research Institute study on the ability of countries to produce organophosphorus nerve agent and munitions.

As for the influence of binary technology on current disarmament negotiations, the question of the ease with which binary weapons can be produced is critical. We have reviewed how disarmament negotiations have become snagged on the issues of verification and compliance. How could future negotiations among nations possessing binaries surmount the obstacles to verification presented by binary components that can be produced at commercial chemical plants?

We found few authors who have even discussed this issue. Robinson (1975), who likens binary weapons to miniaturized nerve gas production plants, states that the appearance of binaries removes much of the value from existing verification studies. According to Robinson, the one verification technique that the binaries have left unscathed is the economic-data monitoring approach based on phosphorus accounting. Other sources we reviewed, however, have identified difficulties with such recordkeeping (Midwest Research Institute, 1970a; Roberts and Romine in SIPRI, 1975). Additionally, Robinson himself points out that the concept of binaries has opened the way to the use of agents, not necessarily organophosphorus, that might have been rejected before on the grounds of their instability.

Lundin (1973) suggests that since binary technology shortens the time between the production and the use of chemical weapons to little or none, countries that could apply the technology before signing a comprehensive disarmament treaty would have a permanent production capability. Lundin points to offensive troop training as an area that would raise the verification issue for nations commanding a binary technology. Robinson (1975) also discusses field-testing and troop-training as areas that might be used for verification purposes. It is important to note, however, that training has not been discussed in the years of disarmament negotiations.

In brief, more work needs to be done. While it seems that binaries present new and possibly greater verification problems, little is known about what the specific problems are or their possible solutions.

SUMMARY AND CONCLUSIONS

We began this chapter with the question of how the modernization of U.S. chemical weapons would affect the prospects for disarmament. We find that it is necessary to look first at the status of disarmament negotiations and the prospects for disarmament without modernization. The general literature shows that progress in chemical warfare negotiations has been slow. Bilateral negotiations between the United States and the Soviet Union have stalled, largely because of verification issues.

A draft paper delivered to the United Nations by the Soviet Union may offer some hope of flexibility in the Soviet position regarding mandatory on-site inspections. ACDA has taken a "wait and see" position while indicating serious problems that remain for verification. We find the verification issues to be complex, but we have identified many areas in which information potentially useful in verification discussions is lacking. We have raised a number of questions that should be addressed:

--What new long-range sensing devices were developed during the past decade?

--To what extent did technological improvements in that decade increase the effectiveness of sensors, space platforms, and "spy in the sky" surveillance?

--How realistic is computer verification? How possible is it technically and how intrusive?

--How intrusive are the various surveillance techniques, how costly are they, and how easy are they to evade?

--What techniques or combinations of techniques yield the greatest probability of detecting compliance violations with the least intrusiveness?

We find many advocates of the position that modernizing the U.S. chemical warfare capability with binary production would result in a negotiations breakthrough and many advocates of the position that it would result in a complete breakdown of negotiations and an arms race. Few data support either position.

We have asked whether binaries would increase the proliferation of chemical weapons and whether they would further complicate the disarmament negotiations. We find that the answers depend on the ease with which binary chemical weapons can be produced and on the complications binaries pose for the already problematic verification issue. The questions are

--What are the relative difficulties of producing binary agents and munitions? How do the difficulties compare for unitaries?

--What countries have the ability to produce binary weapons on a scale large enough to pose a major threat? How does this compare with the situation for unitaries?

--How would the presence of binary chemical weapons affect the value of existing verification studies? What surveillance techniques change on measures of ease of evasion and intrusiveness?

We find that few authors even raise these issues. While it seems that binaries present new verification problems, little is known about what the specific verification problems are or what their solutions might be. The larger question--how likely it is that negotiations among nations that possess binaries will overcome the obstacles to verification posed by binary components that can be produced at commercial plants--remains unanswered.

CHAPTER 6

QUESTIONS ON U.S. CHEMICAL WARFARE CAPABILITY, SUMMARY OBSERVATIONS, AND AGENCY COMMENTS AND OUR RESPONSE

The controversial chemical warfare issue has been raised by the present Administration's plan to modernize the nation's chemical warfare capability. In the 5 years 1983-87, the U.S. Department of Defense anticipates spending between $6 billion and $7 billion to upgrade the U.S. retaliatory and defensive chemical warfare capabilities. With this sum of money at stake, the results of the proposed modernization program range from spending billions of dollars unnecessarily, or even harmfully, to endangering U.S. national security and that of its allies if the money is not spent.

The House Committee on Foreign Affairs asked us to synthesize and assess the nature, extent, and quality of information available to answer the following specific questions:

1. How can chemical warfare be deterred?

2. How do U.S. and Soviet capabilities compare?

3. How can the United States modernize its chemical warfare system?

4. How will modernization affect the prospects for disarmament?

The current debate on the need to increase the U.S. chemical warfare capability usually revolves around one or more of these questions.

Our purpose in synthesizing the information on chemical warfare was to determine (1) what is known about chemical warfare (the facts and other data and the analyses that are available to support various positions), (2) the general confidence that can be placed in that information, and (3) the gaps and inadequacies in it. Toward this end, we reviewed and assessed classified and unclassified chemical warfare literature, focusing on military and other technical documents and on empirical studies. Experts representing different positions on the chemical warfare modernization debate helped us establsh that we had included all major references in our review, indicating sources with additional factual information or arguments we had not already identified. Despite the technical and empirical focus of our review, we found that the arguments in most references are based on belief. Most of the factual information is unsupported by citations. Few simulations or actual test and evaluation studies exist.

We found a multitude of unanswered questions related to chemical warfare modernization. The number of unresolved issues, both broadly and narrowly defined ones, is large. Some questions have been partly and inadequately addressed; others have apparently not even been raised. The general picture is that the chemical weapon system is not perceived as a credible deterrent, little is known about its functioning or its usefulness, and a large amount of money is being sought for it. We are particularly concerned that so many questions remain unanswered since the United States has maintained chemical weapons for so many years and since we have issued a long series of reports identifying deficiencies in U.S. chemical warfare retaliatory and defensive readiness.

HOW CAN CHEMICAL WARFARE BE DETERRED?

The concept of deterrence is generally premised on dissuading hostile actions through the perception of the will and the ability to inflict unacceptable consequences on a potential adversary. Deterring chemical warfare is premised on the same concept, except that analysts differ, according to their individual perspectives on tactical warfare and their views of the utility of chemical weapons, on what specifically is most likely to be able to inflict, and to be perceived as able to inflict, unacceptable consequences. Chief among the views are that the threat of tactical nuclear attack is a credible chemical warfare deterrent and that a chemical retaliatory capability is necessary for deterrence.

The literature also presents the essential elements of retaliatory, or offensive, and defensive chemical warfare capabilities. These elements include (1) having a well-developed doctrine, (2) maintaining a sufficient stockpile of weapons, (3) having delivery systems for the weapons, (4) having adequate and appropriate defensive equipment and personnel, and (5) being able to implement the system. The fifth element includes training, production facilities, and deployment logistics.

Empirical evidence of the significance of these elements in establishing a credible chemical warfare deterrent is scant. The literature suggests that lack of chemical warfare assimilation by the military, legal and moral proscription, and fear of retaliation played important parts in forestalling an extensive use of chemicals in World War II. Historical analyses of alleged uses of chemical weapons suggest that both the ability to defend against an enemy using chemical weapons and the ability to launch a retaliatory attack on the enemy (although not necessarily with chemicals) are important components of deterrence.

The literature identifies three broad policy options for chemical warfare deterrence. Emphasizing different elements of capability, these are policies on arms control, weapons, and defense. Policies emphasizing weapons and defense

call for some offensive or retaliatory capability, whether nuclear or chemical, yet all three require a strong protective posture. The emphasis on weapons differs from the emphasis on defense by calling for a major conventional, nuclear, or chemical warfighting capability; the emphasis on defense includes a limited chemical retaliatory capability, sufficient only to force the enemy into chemical protection.

The issues that are prominent in discussions of these three policy options are (1) the extent to which the use of chemical weapons could be rendered ineffective if protective shelter, clothing, and equipment were adequate to defend against them, (2) the extent to which protective clothing and equipment severely degrade military efficiency on both sides, and (3) the likelihood, necessity for, and utility of a verifiable ban on chemical weapons. Those who argue that strong defensive measures or the threat of tactical nuclear retaliation deter the initiation of chemical warfare generally look favorably on arms control as a way of achieving a chemical weapons ban. Those who disagree with this view and argue for the importance of imposing an equal degradation of performance on an enemy often favor retaliation-in-kind as a chemical warfare policy.

The literature shows that the United States has consistently declared the policy of retaliation-in-kind. Given the existence of the U.S. chemical weapons arsenal and current proposals to upgrade both its retaliatory and its defensive capabilities, the United States can be seen as having adopted either a policy of weapons emphasis or a policy of defense emphasis with limited retaliatory potential. Some argue, however, that U.S. policy should be characterized as emphasizing arms control, since they believe that the United States has been unilaterally disarming.

HOW DO U.S. AND SOVIET CAPABILITIES COMPARE? HOW CAN THE UNITED STATES MODERNIZE ITS CHEMICAL WARFARE SYSTEM?

Whether emphasizing defense with limited retaliatory capability, weapons, or arms control, U.S. chemical warfare deterrence policy requires both chemical retaliatory and defensive, or protective, capabilities. Retaliatory and defensive capabilities consist of many elements, the basic ones listed in the literature being doctrine, stockpile size and composition, delivery systems, defensive equipment and personnel, and implementation. We reviewed the literature to determine U.S. and Soviet status on these elements of capability and investigated DOD's modernization program in light of the current U.S. status.

The literature generally agrees that the United States lacks a credible chemical warfare deterrent in terms of the capability elements. That is, perceptions and data agree that the

United States does not have the means or the ability to respond effectively to a chemical attack. In contrast, the literature generally reflects the perception that the Soviets are highly able to wage chemical warfare. However, open sources and classified reports contain only limited information to support the various assertions about specific levels of Soviet capability.

As for defensive capability, we found a body of facts and supporting evidence that the Soviets have built a strong ability to defend against nuclear, biological, and chemical warfare. We found U.S. inadequacies well-documented with respect to the ability to retaliate and defend in a chemical warfare environment. The most favorable comparison for the United States is in individual protection, but even here the literature describes unresolved problems with the U.S. protective suit and mask.

The question that is implicit in DOD's modernization plan is whether or not modernizing the U.S. chemical warfare capability will improve deterrence. Modernizing a chemical warfare system requires (1) adequate information on the several alternative ways of modernizing, (2) a strong rationale, based on reliable data, for selecting one alternative rather than another, and (3) comprehensive and integrated plans to coordinate the improvement of capability in a variety of elements--among them doctrine, stockpile, delivery systems, defensive equipment, and implementation. In our review of existing information on DOD's modernization program, we did not find convincing evidence that these three requirements have been adequately met.

Doctrine

The following statements are supported by credible information:

--The Soviets are perceived as having a well-developed and clearly articulated offensive chemical warfare doctrine.

--The United States is attempting to develop chemical warfare doctrine.

--There are many combat scenarios in which chemical weapons could be used against U.S. forces and there is no comprehensive U.S. doctrine for sustaining combat operations in many such situations.

Information on the following issues is sparse or inadequate and we are unable to draw conclusions about them with a minimum level of confidence:

--whether the Soviets do have a well-developed and clearly articulated offensive chemical warfare doctrine;

--whether the major obstacles to the development of U.S. chemical warfare doctrine have been identified and whether they can be overcome;

--whether procuring binary weapons will complicate efforts to develop retaliatory doctrine;

--whether U.S. retaliatory doctrine can adequately address the following: the effects of combining chemical weapons and improved conventional munitions in warfare, the likelihood of inflicting casualties on well-protected Soviet troops, the likelihood that area-denial tactics can be pursued given Soviet collective protection capabilities, and the likelihood that U.S. forces can acquire targets most susceptible to chemical attack without causing unacceptable civilian casualties;

--whether in the immediate future U.S. defensive doctrine should be made to reflect the lack of adequate collective protection in combat vehicles and stationary shelters, vehicle and equipment decontamination facilities, and remote-area sensing and alarms.

Stockpile

Regarding the stockpiles of munitions held by the United States and the Soviet Union, our review finds substantial evidence of the following:

--The United States maintains chemical stockpiles in arsenals within the United States, in a depot on Johnston Island in the Pacific, and in Europe.

--Most U.S. munitions are short-range artillery projectiles; the arsenal contains some chemical-filled bombs

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--The stockpile in Europe contains

.

--The total size of the U.S. chemical stockpile and its condition are not precisely known; estimates range consistently from agent tons to agent tons.

--There are approximately agent tons of lethal chemicals in bulk storage in the U.S. stockpile; in addition, there are between agent tons of serviceable or repairable munitions.

--The size, mixture, and deployment of the Soviet stockpile is ; guesses about its size range from agent tons to agent tons, indicating the of knowledge in this area.

The information that is available is inadequate to support conclusions on the following chemical stockpile questions:

--whether comprehensive logistics plans exist for timely deployment of chemical weapons to NATO;

--whether the chemical weapons in Europe are enough to degrade Soviet forces to the same level NATO forces can expect to be degraded;

--what tonnage need in chemical munitions has been estimated for theaters other than NATO's central region;

--the extent of preventative and rehabilitative measures being taken to preserve the existing chemical weapons stockpile;

--whether there is a sound basis for determining a stockpile of munitions that effectively meets the Soviet threat and takes advantage of any of its vulnerabilities.

Delivery systems

Analysis of the literature shows that evidence supports the following assessments of chemical warfare delivery systems:

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--The Army is not following recommendations to produce binary bombs first, rather than artillery projectiles, in order to acquire a long-range capability.

--The Soviet chemical warfare delivery means are virtually unknown, even though many sources cite them as consisting of missiles, rockets, bombs, aerial spray tanks, and artillery.

We found limited information or none on the following delivery issues:

--U.S. progress in developing a long-range surface-to-surface chemical warfare delivery capability;

--U.S. progress in developing short-range chemical warfare delivery means

;

--whether air-delivered chemical munitions are practicable in the face of Soviet anti-aircraft capabilities;

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Defensive equipment

The information on defensive systems supports the following assessments:

--Tests have shown that the U.S. protective suit causes less heat stress than Soviet suits.

--U.S. suits are flammable, cannot be laundered, and must be disposed of when they are saturated.

--U.S. protective masks need a flexible lens and external filters that are easy to change.

--The United States lacks an adequate chemical sensing and alarm capability.

--The United States has limited collective protection capabilities for vehicles; the Soviets have seriously pursued collective protection.

--The United States lacks efficient equipment for the large-scale decontamination of troops, weapons, and vehicles; Soviet forces appear to have a substantial decontamination capability.

--The United States planned to have 7,400 chemical defense specialists by fiscal year 1982; the Soviets have been estimated as having between 50,000 and 100,000 troops dedicated to nuclear, biological, and chemical defense.

Our knowledge is less certain, or nonexistent, on the following points:

--plans for and progress in fitting various existing U.S. combat vehicles for collective protection;

--the operability of Soviet collective protection systems in combat vehicles, as planned, under combat conditions of high mobility and repeated weapon firings.

Implementation

In examining implementation capabilities, we found credible evidence supporting the following statements:

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; the United States does not have plans for deploying binary munitions in Europe.

--

We identified very little information on implementation issues such as whether the operational characteristics of binaries (such as their mixing time) require special training or doctrinal considerations.

In essence, the findings of the literature on the five elements of doctrine, stockpile, delivery systems, defense equipment, and implementation can be summarized as follows:

1. The United States does not have a chemical warfare doctrine, yet DOD is preparing to modernize the chemical weapons arsenal. There is evidence that the Soviets have developed a defensive doctrine for integrated conventional, nuclear, and chemical warfare scenarios; little is known about Soviet offensive doctrine.

2. The precise size and condition of the U.S. stockpile are not known, but it is known that and no long-range surface-to-surface capability at all. Little is known about the size and mixture of Soviet chemical munitions.

3. There appears to be no U.S. plan for developing a long-range surface-to-surface chemical weapons delivery capability. The Soviets are assumed to have every conceivable means of delivering chemical warfare agents, but

4. The United States has put into the field relatively good protective suits but needs to improve decontamination capability, remote area detection, collective protection in vehicles, and stationary shelters, with remote sensing and alarm capability being seen as presenting an especially critical deficiency. The Soviets have made extensive chemical warfare defensive preparations in all areas--decontamination, detection, individual and collective protection.

5. The United States has not pursued initiatives with NATO allies that would allow the forward deployment of binary weapons,

Binary alternatives

Alternatives to the procurement of binary weapons are identified and discussed in the literature. Most commonly it is

argued that the United States has a stockpile of chemical weapons that is sufficient for any likely retaliation-in-kind requirement. The DOD position is that the present stockpile is deficient in both size and mixture of weapons and that only producing binaries will rectify this situation. We find that present knowledge is not adequate either to refute or to support the claims and counterclaims in this debate.

We searched for evidence that indicates that the new binary weapons will give DOD substantial advantages it does not have with the unitary weapons. We found that the following statements are well supported by the available evidence:

--Design characteristics give binary weapons safety features that facilitate their handling, storage, and transportation in peacetime.

--"Arming" the binary weapons diminishes these safety features.

--Open-air testing has been banned since 1969 and as a result no field data have been collected on the performance characteristics of binary weapons.

--Binary weapons require more space for storage and transportation than unitary weapons do. For the 155-mm projectiles, for example, nearly four times as much space is required.

We found little or no information regarding the following issues and, therefore, cannot make conclusions about them with an acceptable level of confidence:

--the extent to which the noise and odor associated with the binary weapons detract from their utility in achieving military objectives;

--the extent to which the technical aspects of binary weapons, including mixing and arming them, place unacceptable constraints on the weapons' tactical utility;

--the extent to which data from simulants are useful in predicting the performance of binary weapons and, therefore, their utility in meeting military objectives;

--whether binary weapons offer significant advantages over unitary weapons on a wide range of operational and technical factors such as dispersion patterns and toxicity levels;

--whether binary chemicals are safe to produce;

--whether procuring binary weapons will significantly improve the U.S. chemical retaliatory capability.

We found that the evidence is generally insufficient for conclusions on the performance advantages of binary weapons compared with unitary weapons. There is support for the assertions about the peacetime safety features of binary weapons, and there are also unexplained indications that these peacetime advantages may have related wartime costs.

HOW DOES MODERNIZATION AFFECT THE PROSPECTS FOR DISARMAMENT?

Having reviewed DOD's plans for chemical weapons modernization, we examined information on the effect modernization is likely to have on the prospects for the ultimate deterrent--a chemical weapons ban. We found a history of slow progress in treaty negotiations, which have been substantially hampered by a lack of agreement on the issues of verification. Although the United States and the Soviet Union have agreed that the verification of a chemical weapons treaty should be based on a combination of national and international measures, the Soviets have consistently rejected requests for on-site verification of treaty provisions. A draft paper delivered in 1982 to the United Nations by the Soviet Union may offer some hope of flexibility in the Soviet position, but the Arms Control and Disarmament Agency is taking a "wait and see" attitude toward the draft paper. The verification issues are complex, and in many areas information potentially useful in resolving them is lacking.

For example, we found no objective evaluations of whether using several nonintrusive verification techniques at one time would bolster the likelihood of detecting activities related to chemical weapons. In addition, we found that a number of pertinent questions have not been addressed:

--Have technological advances in the last decade made long-range sensing devices (such as remote sensors in air or on space platforms) likely verification tools?

--Is computer-based verification realistic and not overly intrusive?

--What techniques or combination of techniques give the greatest probability of detecting treaty violations?

As to whether U.S. chemical warfare modernization plans would result in a negotiations breakthrough or breakdown, we found advocates for both positions but little data. The arguments depend on beliefs about how a U.S. chemical weapons build-up would be perceived. We inquired whether procuring binary chemical weapons would mean a proliferation of chemical weapons and a further complication of disarmament negotiations. Arguments on these issues depend on how easily binary weapons can be produced and the way in which binary weapons would further complicate the already complex verification issue. Resolution of the arguments will require answers to these questions:

(1) How easily can binaries actually be produced? (2) What nations have the ability to produce binaries? (3) How would producing binaries affect the value of existing verification procedures? We find that these questions are rarely enunciated and even more seldom analyzed.

SUMMARY OBSERVATIONS

The general impression left by the literature is that there is little empirical data in areas pertaining to the functioning and usefulness of chemical weapons. Conjecture plays a major role in the formulation of theories of chemical warfare deterrence and in the analysis of Soviet threats and U.S. responses. We offer the following seven observations on primary information needs.

Observation 1

The literature agrees that more reliable information is needed on Soviet offensive capabilities. The evidence is strong that the Soviets have been building their nuclear, biological, and chemical defensive capabilities, but this does not necessarily imply, as is sometimes assumed, that U.S. retaliatory chemical warfare capabilities require strengthening.

Observation 2

It is argued reasonably in the literature that some retaliatory chemical capability is necessary in order to degrade enemy performance and remove the potential advantage of an enemy's using chemical weapons, but the literature shows no analysis of the proportion of chemical to nonchemical munitions that would be required to achieve this objective. No analysis identifies the implications for the U.S. stockpile when degradation is the major military objective.

Observation 3

The literature does not conclude that chemicals are tactically more advantageous than other weapons in achieving military objectives other than the degradation of an enemy's performance. There seems to be no information on the comparative ability of chemical and other weapons, alone and in combination, to cause casualties in attacking specific battlefield targets. If analysis is to be conducted, it should assume a well-protected enemy, given what is known about Soviet defensive capabilities.

Observation 4

Comparative analyses of the effectiveness of the various chemical delivery systems have not been made. The literature is confined to concern about reliance on the Bigeye bomb for long-range capability.

Observation 5

Despite the fact that a simulation sponsored by the Joint Chiefs of Staff indicates that as much as

, there is no evidence that steps are being taken to protect civilian populations in the event of a chemical war.

Observation 6

The literature shows that historically chemicals have been used in warfare in only limited ways because chemical warfare has never been assimilated into armed forces procedures, preparing everyone on the battlefield with respect to chemical weapons so that they know what to do, how to do it, when to do it, and what will happen if it is done. The literature shows that it has still not been assimilated.

. However, the simulation study sponsored by the Joint Chiefs of Staff indicates that, in a European conflict,

. The question of a chemical versus a tactical nuclear response, and the associated costs, deserves further analysis.

Observation 7

Given the implications for national security and dollar expense in DOD's proposal to modernize U.S. chemical warfare capability by producing binary weapons, the literature contains surprisingly little analysis of the advantages and disadvantages of these weapons compared with the unitary weapons they would replace. What is known about the ability of other countries to produce nerve agent and munitions should be brought up to date in a way that considers their binary capabilities and identifies the implications for the issue of the verification of a weapons ban.

AGENCY COMMENTS AND OUR RESPONSE

Draft copies of this report were submitted to DOD for comment on December 9, 1982, and we granted a request for additional time beyond the customary 30 days for review, extending DOD's comment period to January 21, 1983. On January 24, 1983, we met with DOD officials at the Pentagon. Our representatives were advised that written comments would not be available and that the purpose of the meeting was to provide us with official oral comments on the draft report. These official oral comments were presented by Dr. Theodore Gold, the Deputy Assistant to the Secretary of Defense for Chemical Matters. Dr. Gold began his comments by acknowledging a need for good analyses on chemical

warfare. We concurred with this view and indicated that we were aware that his office was proposing to sponsor analyses, through the Institute for Defense Analyses, on chemical warfare joint test and evaluation. We also indicated our familiarity with previous IDA analyses on chemical warfare. After this preliminary, Dr. Gold presented four points as the official DOD comments on this report.

DOD point 1

A literature review is not an adequate method for addressing issues in this area because some relevant information is not in documented form. Moreover, the draft report does not cover some documents that are pertinent to the issues. Giving an example of the limitation of a literature review as a basis for addressing issues in this area, Dr. Gold cited our discussion in the report of the size and condition of the U.S. chemical stockpile. He contended that quoting figures from various documents written over a period of several years does not constitute an adequate basis for judging stockpile size or condition. He noted that DOD had recently attempted to assess the chemical weapons stockpile.

Our response

We informed Dr. Gold that we used several techniques in preparing the report. We reviewed the literature but we also made use of a panel of experts, who assisted us in determining which documents to include in our review. We assessed the value of each document in terms of how well it supported its conclusions and the degree to which its findings were reinforced by similar conclusions in other studies. We incorporated information from interviews we held with officials of DOD, including the armed services, and with notable experts and independent researchers. In the course of collecting data, we attended briefings and congressional hearings on chemical warfare issues. The information we gained in these activities supplemented the information we gathered from the literature and helped us identify the major issues in the subject of chemical warfare. (In chapter 1, we present full details of our methodology).

With regard to the stockpile example Dr. Gold raised, we informed him that we used two recent documents sponsored by DOD to address stockpile issues in our report--the 1981 Defense Science Board study and DOD's 1982 report to the Congress on chemical warfare. When we asked Dr. Gold for documentation on the more recent DOD efforts to assess the stockpile size and condition, he did not provide any additional sources.

DOD point 2

The report does not provide a balanced and complete picture of the important issues in chemical warfare. Giving an example,

Dr. Gold stated that we had not reviewed primary intelligence data regarding an enemy's threat of using chemical weapons.

Our response

We discussed with Dr. Gold and the DOD officials how we used intelligence information, and we agreed to clarify the report to show that we did not use primary intelligence data, did not challenge any intelligence data, and accepted at face value and used intelligence information that is cited in DOD documents. We also pointed out that the Central Intelligence Agency reviewed a draft of the report and did not challenge the way we have referred to intelligence information.

DOD point 3

The report contains many factual errors and errors of omission, and there is additional documentation that would have been of assistance in the preparation of the report.

Our response

We requested Dr. Gold to support his statement that the report contains many factual errors. However, he offered us no examples of error in the report, responding only that DOD did not make a line-by-line review. When we asked for the titles and sources of the additional documentation that Dr. Gold had referred to, none were given.

DOD's point 4

GAO did not work through Dr. Gold's office and did not talk to responsible officials in DOD or the individual services.

Our response

Regarding Dr. Gold's concern that we did not work with his office and did not talk with responsible officials, we pointed out that we had conducted the interview and data collection phase of our work before he arrived at DOD and that we will make this clearer in the report. We also presented him with a list of individuals in DOD and the services whom we made contact with during our audit. The list includes Major General Niles Fulwyler and members of his staff (his office served as the Army's focal point for chemical warfare matters during the period of our review), Colonel John Tengler of the Joint Chiefs of Staff, Victor Utgoff and Colonel Horace Russell of the National Security Council, Robert Mikulak of the Department of State, and Professor John Deutch of the Massachusetts Institute of Technology (during a briefing on chemical warfare that he presented at the MITRE Corporation). We added that we had attended and obtained testimony presented to the Senate Appropriations Committee in May 1982 by Dr. Richard L. Wagner, the Assistant to

the Secretary of Defense for Atomic Energy, by Dr. Theodore Gold, the Deputy Assistant to the Secretary of Defense for Chemical Matters, and by the Honorable James F. Leonard, former Ambassador and senior official in the Arms Control and Disarmament Agency on chemical and biological warfare issues. Dr. Gold indicated that Amoretta Hoeber, the Principal Deputy Assistant Secretary of the Army for Research, Development, and Acquisition, has no records indicating that she received, reviewed, and commented on the list of sources we compiled for this report. We replied to Dr. Gold that we can provide documentation that verifies that she did review a draft version of our bibliography (printed as appendix II in this report).

We have revised the report so that it includes a discussion of how we treated intelligence information, which we hope clarifies the concern that DOD raised. The other official comments were so general that, without more specific reference, we were unable to make any revision that could be based on them.

We received a written response from DOD well past the established time for the submission of agency comments. However, since it documents the oral presentation we have discussed above, we have included it in the final report in appendix IV. The letter of response we sent to DOD is also printed in appendix IV.

APPENDIX I

Congress of the United States
Committee on Foreign Affairs
House of Representatives
Washington, D.C. 20515

March 18, 1982

Mr. Charles A. Bowsher
Comptroller General of the United States
General Accounting Office
Room 7026
441 G Street, N.W.
Washington, D.C. 20548

Dear Mr. Bowsher:

The Subcommittee on International Security and Scientific Affairs is preparing for hearings on chemical warfare. Information describing deterrence against use of chemical weapons, Soviet and U.S. chemical warfare capabilities, binary chemical weapons, and disarmament would be very valuable to the Subcommittee in preparing for hearings. More specifically, the Subcommittee is interested in obtaining information on the fifteen questions presented in the attachment to this letter.

Discussion between my Staff Director, Ivo Spalatin, and staff from your Institute for Program Evaluation indicated that the Institute would be able to provide us with information in time for our hearings. It would be most helpful to us if the Institute staff could synthesize and assess the currently existing information on these fifteen questions and brief us on what they have learned no later than April 7, 1982 with a written report to follow as soon as possible thereafter.

Thanking you in advance for your cooperation in responding to this request, I am

Sincerely yours,

Clement J. Zablocki

Chairman

CJZ:isj

attachment

APPENDIX I

Attachment

Questions for Analysis Based on Existing Information

Topic 1. Deterrence.

1. What are the different ways to achieve deterrence against use of chemical weapons and which way has the U.S. chosen to pursue it?

Topic 2. Soviet Capability

(2) What is the nature, extent, and condition of the Soviet stockpile?

(3) To what extent do the Soviets have chemical weapons production/ research facilities?

(4) What chemical weapons delivery systems do the Soviets have?

(5) What is the Soviet CW defensive capability?

Topic 3. U.S. Offensive Capability

(6) What is the current U.S. chemical warfare doctrine?

(7) How has the needed U.S. stockpile size been determined?

(8) Are munitions in our current stockpile compatible with delivery systems introduced or being introduced in Europe?

(9) What other options, besides the binary, exist for modernizing our chemical warfare capability?

Topic 4. Binary Chemical Weapons

(10) Will the binary program affect the U.S. ability to achieve both a CW denial and punishment capability?

(11) How would deployment of binary munitions affect military operational flexibility?

(12) How do binary and unitary munitions compare in toxicity?

(13) How do unitary and binary weapons compare in safety?

(14) To what extent will binaries increase the risk of proliferation?

Topic 5. Disarmament

(15) What are the verification problems with regard to a chemical weapons ban?

BIBLIOGRAPHY

We have organized the references in this bibliography alphabetically by author within categories. In order, the categories are as follows:

--reports by congressional agencies and organizations,

--military and technical journal articles,

--other military publications,

--publications by other organizations,

--conference papers and testimony,

--books by individuals.

REPORTS BY CONGRESSIONAL AGENCIES AND ORGANIZATIONS

DEMOCRATIC STUDY GROUP. Nerve Gas Production. Washington, D.C.: September 5, 1980.

General Accounting Office. Strong Central Planning and Direction Needed to Guide the Services' Chemical Warfare Programs, PLRD-82-13, CONFIDENTIAL. Washington, D.C.: July 20, 1982.

-----. Status of DOD's Implementation of GAO's Recommendations Concerning Chemical Munitions and Agents, PLRD-81-1, SECRET. Washington, D.C.: June 15, 1981.

-----. Models, Data, and War: A Critique of the Foundation for Defense Analyses, PAD-80-21. Washington, D.C.: March 12, 1980.

-----. U.S. Chemical Munitions: Current Status of Issues Facing the Congress, PSAD-79-57, SECRET. Washington, D.C.: March 16, 1979.

-----. U.S. Chemical Warfare Defense: Readiness and Costs, PSAD-77-105, SECRET. Washington, D.C.: November 18, 1977a.

-----. U.S. Lethal Chemical Munitions Policy: Issues Facing the Congress, PSAD-77-84, SECRET. Washington, D.C.: September 21, 1977b.

-----. Stockpile of Lethal Chemical Munitions and Agents--Better Management Needed, LCD-77-205, SECRET. Washington, D.C.: September 14, 1977c.

KALLIS, E. M. Chemical Warfare: Background and Issues. Washington, D.C.: Congressional Research Service, July 8, 1981a.

KALLIS E. M. Chemical Warfare: A Primer on Agents, Munitions, and Defensive Measures. Washington, D.C.: Congressional Research Service, April 27, 1981b.

McCULLOUGH, James M. Chemical and Biological Warfare: Selected Issues and Developments During 1978 and January 1-June 30, 1979. Washington, D.C.: Congressional Research Service, July 1, 1979.

MEMBERS OF CONGRESS FOR PEACE THROUGH LAW. Binary Chemical Weapons. Washington, D.C.: September 5, 1980.

MILITARY AND TECHNICAL JOURNAL ARTICLES

BARNABY, Frank. "CBW--An Unresolved Horror." Bulletin of Atomic Scientists, June 1980, pp. 8-10.

BAY, Charles H. "An Update on the Other Gas Crisis: Chemical Weapons." Parameters: Journal of the U.S. Army War College, December 1980a, pp. 27-35.

-----. "Anthrax: Recipe for a Blunt Weapon." Scientist, September 1980b, pp. 721-22.

-----. "Death at Sverdlovsk: A Critical Diagnosis." Science, September 1980c, pp. 1501-02.

-----. "Clouds of Doubt: 'Germ Warfare' Violation Hard to Pin Down." Bioscience, July 1980d, pp. 485-87.

-----. "Chemical Warfare and the Military Balance." Parameters: Journal of the U.S. Army War College, 7 (1977), pp. 39-53.

CENTER FOR DEFENSE INFORMATION. "Old Fears, New Weapons: Brewing a Chemical Arms Race." The Defense Monitor, 9 (1980), 1-8.

"Chemical Arms: A Sea of Troubles." Nature, April 3, 1980, p. 387.

DASHIELL, Thomas. "A Realistic Look at Chemical Warfare." Defense, January 1981, pp. 16-20.

DICK, C. J. "Soviet Chemical Warfare Capabilities." International Defense Review, 14 (1981), 31-38.

DONNELLY, C. N. "Winning the NBC War: Soviet Army Theory and Practice." International Defense Review, 14 (1981), 989-96.

EMBER, Lois R. "Chemical Weapons: Build Up or Disarm?" Chemical & Engineering News, December 15, 1980, pp. 22-27.

ERICKSON, J. "The Soviet Union's Growing Arsenal of Chemical Warfare." Strategic Review, 7 (1979), 63-71.

FINAN, J. S. "Soviet Interest in and Possible Tactical Use of Chemical Weapons." Canadian Defense Quarterly, 4 (1974) 11-15.

HALL, Peter. "Nerve Gas Politics." Progressive, September 1980, pp. 42-44.

HOEBER, Amoretta, and Joseph D. Douglass, Jr. "The Chemical Warfare Problem." Washington Report, August 1978a, pp. 1-8.

-----. "The Neglected Threat of Chemical Warfare." International Security, 3 (1978b), 55-82.

HOLDEN, Constance. "Binary Nerve Gas Production Plans Debated." Science, April 30, 1982, pp. 495-98.

HOSKIN, F. C., and A. H. Roush. "Hydrolysis of Nerve Gas by Squid Type Diisopropyl Phosphorofluoridate Hydrolyzing Enzyme on Agarose Resin." Science, March 5, 1982, pp. 1255-57.

KITMAN, Jamie. "A Nerve Gas We Can Love." The Nation, July 5, 1980, pp. 12-14.

KYLE, Deborah M. "NATO's Chemical Warfare Defense: Improving but Inadequate." Armed Forces Journal International, November 1980, pp. 33-34.

LENOROVITZ, Jeffrey. "USAF Improving Defenses Against Chemical Threat." Aviation Week & Space Technology, May 19, 1980, p. 109.

-----. "USAF Trains Against Chemical Warfare." Aviation Week & Space Technology, July 23, 1979.

LEPKOWSKI, W. "Chemical Warfare: One of the Dilemmas of the Arms Race." Chemical & Engineering News, January 2, 1978, pp. 16-20.

LUNDIN, J. S. "Chemical Weapons: Too Late for Disarmament?" Bulletin of the Atomic Scientists, December 1979, pp. 33-37.

-----. "The Scope and Control of Chemical Disarmament Treaties Particularly with Regard to Binary Chemical Weapons." Cooperation and Conflict, 8 (1973), 143-53.

LYONS, Gene. "Invisible Wars." Harper's, December 1981, pp. 37-52.

MESELSON, Matthew, and Julian Perry Robinson. "Chemical Warfare and Chemical Disarmament." Scientific American, April 1980, pp. 38-47.

MILLER, E. A., and H. H. Cooksey. "Speaking on . . . Evaluation of Soviet's Overall Threat: Analysis of Potential Factors." Army Research & Development News Magazine, 18 (1977), 1,22-23.

MILSTEIN, M. A., and M. A. Semejko. "U.S. Military 'R&D' Through Soviet Eyes." Bulletin of the Atomic Scientists, February 1977, pp. 32-39.

PAXMAN, Jeremy. "Poison Gas: A Higher Form of Killing." The Listener, June 5, 1980, pp. 706-08.

PONTE, Lowell. "Demilitarizing Chemical Munitions." Army Logistician, 12 (1980a), 14-16

-----. "The Dawning Age of Technoterrorism." Next, 1 (1980b), 49-54.

PRINGLE, Peter. "Chemical Munitions to Cost $9 Billion." Defense Week, February 22, 1982, p. 1.

ROBERTS, G. "The Campaign of Misinformation." New Statesman, April 4, 1980, pp. 504-06.

ROBINSON, J. Perry. "Chemical Weapons and Europe." Survival, 24 (1982), 9-18.

-----. "Chemical Arms Control and the Assimilation of Chemical Weapons." International Journal, 12 (1981), 515-34.

ROLAND, Neil. "Binary Weapon Debate Centers on Performance." Army Times, April 12, 1982a, p. 10.

-----. "Chemical Weapons Bid by Army Spurs Debate." Army Times, April 5, 1982b, pp. 1 and 16.

VOLZ, Arthur. "Soviet Warfare Capability." Radio Liberty Research, October 11, 1976, pp. 1-5.

WALSH, L. Thomas. "The Modern Barbarians." Armed Forces Journal International, July 1980, pp. 50-53.

OTHER MILITARY PUBLICATIONS

ARMY COMBAT DEVELOPMENTS EXPERIMENTATION COMMAND. Grant Plot III, CONFIDENTIAL. Fort Ord, Calif.: March 1976.

ARMY DUGWAY PROVING GROUND. Proposed Test/Study Programs for Joint Chemical/Biological Contact Point and Test, SECRET. Dugway, Utah: January 1981.

ARMY SCIENCE BOARD. Chemical Decontamination/Contamination Avoidance, Vol. 2, Appendices, SECRET. Washington, D.C.: May 15, 1979a.

-----. Evaluation of the Army's Accelerated R&D Program on Chemical Decontamination/Contamination Avoidance, SECRET. Washington, D.C.: May 15, 1979a.

BAIRD, Richard J. Lethal Chemical Warfare: Option or Myth. Carlisle Barracks, Pa.: Army War College, October 18, 1974.

BAY, Charles H. The Other Gas Crisis: Chemical Weapons. Carlisle Barracks, Pa.: Army War College for the Strategic Studies Institute, June 30, 1979.

CALVERT, Jack F. The Role of Chemical Weapons as a Deterrent to Their Use in Future Conflicts. Carlisle Barracks, Pa.: Army War College, October 23, 1974.

CLAIBORNE, J. David. Mechanical Modeling of Personnel Degradation, Vol. 1, Background Information and Theory. Columbia, Md.: AMAF Industries for Army Armament Research & Development, Arms Control and Disarmament Agency, December 1979.

CRELLING, J. Kenneth. Chemical Warfare Capabilities--Warsaw Pact Countries. Charlottesville, Va.: Army Material Development and Readiness Command Foreign Science and Technology Center, October 31, 1979.

DEFENSE INTELLIGENCE AGENCY. CBR Protection of Soviet Ground Forces. Washington, D.C.: June 1980.

DEPARTMENT OF DEFENSE. Report to the Congress on Chemical Warfare, SECRET. Washington, D.C.: March 1982.

DEPARTMENT OF STATE. "Reported Use of Lethal Chemical Weapons in Afghanistan and Indochina." Department of State Bulletin, 80 (1980), 35.

DEPARTMENT OF THE ARMY. Army Field Manual FM 3-10: Employment of Chemical Agents. Washington, D.C.: February 26, 1971.

DEPARTMENTS OF THE ARMY, NAVY, and AIR FORCE. Employment and Chemical Weapons, rev. ed. Washington, D.C.: February 1971.

HAIG, Alexander M. Chemical Warfare in Southeast Asia and Afghanistan, Special Report 98. Washington, D.C.: Department of State, March 22, 1982.

MILLER, M. R. Operational Degradation of Soviet Artillery from Chemical Attacks, SECRET. Aberdeen Proving Ground, Md.: U.S. Army Material Systems Analysis Activity, September 1980.

MONOHAN, Mark C. Nuclear, Biological and Chemical Defense (NBCD) Readiness in the Mid-Range Period (1978-1990), SECRET. Washington, D.C.: Marine Corps, May 1980.

SCHECTER, G., R. Stricklett, and D. Parker. Urban Warfare: Chemical and Biological Operations, SECRET. Dugway, Utah: Army Dugway Proving Ground, June 1978.

SMITH, Paul E. Riot Control Agents in Southeast Asia. Maxwell Air Force Base, Ala.: Air Command and Staff College, May 1980.

STRATEGIC STUDIES INSTITUTE. NATO Chemical Warfare Policy, SECRET. Carlisle Barracks, Pa.: Army War College, August 1981a.

-----. NATO Chemical Warfare Policy: Study Brief. Carlisle Barracks, Pa.: Army War College, August 3, 1981b.

TEMPLETON, J. L. A Credible Chemical Defense: Fact or Fantasy. Carlisle Barracks, Pa.: Army War College, October 20, 1975.

VERNA, J. B. A Review of the Chemical Warfaring Capabilities of the Soviet Union and the United States, SECRET. Maxwell Air Force Base, Ala.: Air Force Air War College, April 1977.

PUBLICATIONS BY OTHER ORGANIZATIONS

ASSOCIATION OF THE UNITED STATES ARMY. A Chink in Our Armor: The Urgent Need for Chemical Weapons: A Special Report. Arlington, Va.: n.d.

BARNABY, Frank, and R. Huisken. Arms Uncontrolled. Cambridge, Mass.: Harvard University Press for the Stockholm International Peace Research Institute, 1975.

BARTON, John H., and Lawrence D. Weiler, eds. International Arms Control: Issues and Agreements. Stanford, Calif.: Stanford University Press for the Stanford Arms Control Group, 1976.

CARLTON, David, and Carlo Schaerf, eds. The Dynamics of the Arms Race, papers presented at the International School of Disarmament and Research on Conflicts. New York: John Wiley & Sons, 1975.

CARPENTER, William M., et al. Evaluation of Chemical Warfare Policy Alternatives 1980-1990. Menlo Park, Calif.: Stanford Research Institute, Strategic Studies Center, for the Office of the Assistant Secretary of Defense, February 1977.

COMMITTEE ON DISARMAMENT. U.S.S.R.--United States Joint Report on the Progress in the Bilateral Negotiations on the Prohibition of Chemical Weapons. Geneva: July 7, 1980.

DAVENPORT, C. M. Implications for Arms Control Negotiations of U.S.S.R./WP and U.S./NATO Chemical Warfare Capabilities, Vol. 2, Basic Report, SECRET. Menlo Park, Calif.: Stanford Research Institute, Strategic Studies Center, for Department of the Army, April 1974.

DEFENSE SCIENCE BOARD. Report of the Defense Science Board Summer Study on Chemical Warfare, SECRET. Washington, D.C.: Office of the Under Secretary of Defense for Research and Engineering, January 1981.

FOSTER, R. B., et al. Limited Strategic Operations, SECRET. Menlo Park, Calif.: Stanford Research Institute, Strategic Studies Center, for the Assistant Secretary of Defense for International Security Affairs, May 27, 1971.

HOEBER, A. M. Bibliography on Chemical Warfare. Arlington, Va.: System Planning Corporation for the Assistant to the Secretary of Defense for Atomic Energy, May 1980.

INSTITUTE FOR DEFENSE ANALYSES. The IDA Tactical Warfare Model: A Theater-Level Model of Conventional, Nuclear, and Chemical Warfare, Vol. 3, Part 1, The Chemical Model and Other Modifications. Arlington, Va.: Studies, Analysis, and Gaming Agency for the Pentagon, 1970.

JWK INTERNATIONAL CORP. An Investigation of Doctrine and Training Requirements for U.S. Navy Chemical, Biological, Radiological (CBR) Defense, SECRET. Annandale, Va.: Naval Surface Weapons Center, March 14, 1980.

KERLIN, E. P., A. J. Rolfe, and J. E. Shafer. Chemical Warfare in Central Europe, Circa 1986, SECRET. Arlington, Va.: Institute for Defense Analyses for the Organization of the Joint Chiefs of Staff, December 1981.

KERLIN, E. P., D. L. Moody, and A. J. Rolfe. A Study of Chemical Warfare in Central Europe, SECRET. Arlington, Va.: Institute for Defense Analyses for the Organization of the Joint Chiefs of Staff, July 1980.

KOVACS, Stephen Z. Soviet Chemical Troops: An Analysis of Articles in Military Herald. New York: Army Russian Institute, 1979.

MIDWEST RESEARCH INSTITUTE. Arms Control Studies in Chemical and Biological Warfare, Vol. 1, Introduction and Summary. Kansas City, Mo.: Arms Control and Disarmament Agency, 1970a.

-----. Arms Control Studies in Chemical and Biological Warfare, Vol. 2, Inspection-Verification of Chemical Warfare Activities, SECRET. Kansas City, Mo.: Arms Control and Disarmament Agency, December 1970.

STOCKHOLM INTERNATIONAL PEACE RESEARCH INSTITUTE. World Armaments and Disarmament, SIPRI Yearbook 1981. London: Taylor & Francis, 1981.

-----. Chemical Weapons: Destruction and Conversion. London: Taylor & Francis, 1980a.

STOCKHOLM INTERNATIONAL RESEARCH INSTITUTE. World Armaments and Disarmament, SIPRI Yearbook 1979. London: Taylor & Francis, 1979.

-----. Chemical Disarmament: New Weapons for Old. Stockholm: Almqvist & Wiksell, 1975.

-----. The Problem of Chemical and Biological Warfare. Stockholm: Almqvist & Wiksell, 1971-75. 6 Vols.

-----. Chemical Disarmament: Some Problems of Verification. Stockholm: Almqvist & Wiksell, 1973.

UNITED NATIONS, Secretary-General. Basic Problems of Disarmament. New York: 1970.

CONFERENCE PAPERS AND TESTIMONY

AMERICAN DEFENSE PREPAREDNESS ASSOCIATION. NBC Defense Systems Symposium Summary, CONFIDENTIAL. Alexandria, Va.: January 31, 1980.

MESELSON, Matthew, ed. Chemical Weapons and Chemical Arms Control, papers and discussion from a conference at the American Academy of Arts and Sciences, Boston, Mass., January 21-22, 1977. New York: Carnegie Endowment for International Peace, 1978.

RUTMAN, Robert J. "Binary Chemical Weapons: Details, Difficulties and Dangers." Binary Weapons and the Problem of Chemical Disarmament: A Report of the Committee on Chemistry and Public Affairs. Washington, D.C.: American Chemical Society, December 1977.

UNITED STATES, House of Representatives. Testimony at hearings on foreign policy and arms control before the Subcommittee on International Security and Scientific Affairs of the Committee on Foreign Affairs. Washington, D.C.: July 13, 1982.

-----. The Role of Intelligence in the Foreign Policy Process. Hearings Before the Subcommittee on International Security and Scientific Affairs of the Committee on Foreign Affairs. Washington, D.C.: January 28-February 20, 1980.

-----, Senate. "Proceedings and Debate on Amendment No. 56 to Add Funds for a Binary Chemical Munitions Production Facility." Congressional Record, May 21, 1981, pp. 55431-41.

-----. "Statement of Mr. Heflin on the Russian Chemical Warfare Menace." Congressional Record, June 30, 1980, pp. 58853-55.

BOOKS BY INDIVIDUALS

BROWN, Frederic J. Chemical Warfare: A Study in Restraints. Princeton, N.J.: Princeton University Press, 1968.

HART, B. H. Lidell. Deterrent or Defense: A Fresh Look at the West's Military Position. New York: Praeger, 1960.

HERSH, Seymour M. Chemical and Biological Warfare: America's Hidden Arsenal. Indianapolis, Ind.: Bobbs-Merrill, 1968.

HOEBER, Amoretta M. The Chemistry of Defeat: Asymmetries in U.S. and Soviet Chemical Warfare Postures. Cambridge, Mass.: Institute for Foreign Policy Analysis, December 1981.

KISSINGER, Henry A. The Necessity for Choice: Prospects of American Foreign Policy. New York: Harper & Row, 1962.

NERLICH, Uwe. "Chemical Warfare Policy Alternatives: Defense and Negotiations Options." NATO's Strategic Options: Arms Control and Defense, ed. by D. S. Yost. Elmsford, N.Y.: Pergamon Press, 1981.

ROSE, Steven, ed. Chemical and Biological Warfare. Boston, Mass.: Beacon Press, 1981.

ROTHSCHILD, J. H. Tomorrow's Weapons: Chemical and Biological. New York: McGraw-Hill, 1964.

SEAGRAVE, Sterling. Yellow Rain: A Journey Through the Terror of Chemical Warfare. New York: M. Evans and Co., 1981.

ENUMERATION OF INFORMATION SOURCES

The two tables in this appendix show the number of documents we reviewed that address each question number shown in table 2 (p. 5) by document type, following definitions in table 3 (p. 8), and by bibliographic category, following the organization of appendix II (pp. 109-17).

No. of documents addressing question by document type

	1.1	1.2	1.3	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	4.1	4.2	4.3
Historical	2	0	0	0	0	0	0	2	0	0	0	5	4	1
Opinion	8	5	5	7	10	9	11	13	4	2	6	6	6	6
Issue review	4	2	2	4	12	9	9	6	1	3	6	3	3	8
Issue analysis	8	5	3	10	13	7	9	7	4	5	8	7	11	7
Policy study	3	3	2	2	3	3	3	2	1	2	3	3	3	2
Simulation	0	0	1	0	1	1	1	0	1	1	1	0	1	0
Documentary	0	0	0	3	1	1	11	2	10	0	2	2	0	0
Test and evaluation	0	0	0	4	4	3	6	5	4	3	2	0	1	0

No. of documents addressing question by bibliographic category

	1.1	1.2	1.3	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	4.1	4.2	4.3
Reports by congressional agencies and organizations	1	0	1	3	7	4	5	3	3	5	6	2	1	4
Military and technical journal articles	4	3	3	6	16	11	16	14	4	2	8	7	7	10
Other military publications	6	5	3	7	5	5	9	11	3	1	1	2	2	2
Publications by other organizations	3	2	2	4	9	8	9	7	4	7	8	9	15	6
Conference papers	5	4	2	9	8	5	14	4	11	1	4	3	1	1
Books by individuals	5	2	2	3	4	3	2	2	0	0	2	1	1	1

APPENDIX IV

THE UNDER SECRETARY OF DEFENSE

WASHINGTON, D.C. 20301

RESEARCH AND ENGINEERING

4 FEB 1993

Ms Eleanor Chelimsky
Director, Institute for Program Evaluation
U.S. General Accounting Office
Washington, D. C. 20548

Dear Ms Chelimsky:

This is the Department of Defense response to your draft report entitled "Will the Billions of Dollars for the Chemical Warfare Modernization Program Accomplish Its Stated Objectives?", Code 973544 (OSD Case 6152). Fulfillment of this report's intent (as stated on page 1) could have provided valuable assistance to elevate and inform the current national debate on how best to eliminate the threat of chemical warfare (CW). However, as currently written, the report does not provide a complete, accurate, or balanced review of the questions (as was the stated purpose of the effort), or offer any recommendations for action to those responsible for administering the program. As a result, the report does not provide useful views and data that will raise the level of debate, or enhance the knowledge or understanding of either responsible proponents or critics of the CW Modernization Program.

As acknowledged in the report, Soviet CW capabilities, US arms control efforts, and the DOD program to deter chemical warfare are addressed and assessed using as a basis only a literature review. The auditors did not review intelligence data, did not talk to responsible officials, did not read Congressional testimony, did not visit facilities and installations, did not review pertinent arms control verification documents, and did not review applicable service manuals and plans. In short, critically pertinent information and sources necessary to an informed judgment were omitted from the review.

The report indicates that there are a "multitude of unanswered questions." Many of the questions appear unanswered, because the proper source was not contacted and pertinent questions were not raised during the audit. For example, DOD has an office--Office of the Deputy Assistant to the Secretary of Defense (Chemical Matters)--that is the focal point for all chemical warfare matters, but that office was not contacted during the course of the audit. An example of the limitations of the report's literature search approach is found on page 6-9, where the authors state that "The total size of the US chemical stockpile and its condition are not precisely known; our review

APPENDIX IV

consistently found estimates ranging from * agent tons to * agent tons." These estimates were apparently extracted from a variety of documents written over a period of years. These sources do not constitute an adequate basis to judge what DOD believes is the pertinent question. That is, does the current custodian of the chemical stockpile know its size and composition? As far as we can determine, the auditors made no attempt to evaluate DOD's current state of knowledge, or to evaluate its recent effort to assess stockpile conditions. This type omission is evident throughout the report, rendering it unreliable as a guide to understanding the issues, even if the audit had not been based entirely on an incomplete literature review.

The study and identification of the true points of contention in the important and emotionally-charged issues surrounding the CW Modernization Program would be a valuable asset to a national debate. Alternatively, a comprehensive discussion of the substantive positions of both proponents and critics of modernization of our CW deterrent capability would be of great value. Although review of this draft report shows it will contribute to neither objective, DOD will continue to cooperate in any effort to illuminate the key issues involved in the central objective of eliminating the threat of chemical warfare.

Sincerely,

Jim Wade

James P. Wade, Jr.
Principal Deputy Under Secretary of
Defense [illegible]

* Numbers are classified.

APPENDIX IV

UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

INSTITUTE FOR PROGRAM
EVALUATION

February 22, 1982

Mr. James P. Wade, Jr.
Principal Deputy Under Secretary of
Defense for Research and Engineering
Department of Defense

Dear Mr. Wade:

Thank you for your letter of February 4 giving me the written position of the Department of Defense (DoD) on our Chemical Warfare paper. As you know, your letter was delayed beyond the time which GAO allocates for agency comments (DoD had the full 30 days, plus a 10-day extension requested by your staff and granted by GAO). However, since your letter contains no new information and reiterates some of the points already made to us by your staff in the official "verbal comments" session of January 24, you may be sure that we have carefully considered all of your points and that we will be responding generally to the DoD comments in our report.

One thing you may want to note: I think we are in presence of a misunderstanding about the nature of our report methodology: it is neither a "literature review" nor an audit. It is an information synthesis which does indeed begin with a literature review but goes very much further, analyzing the quality of each piece of information (in terms of the evidence supporting it) with an end-product of refined information about the state of knowledge in a particular area at a particular time.

The purposes of such an effort are: (1) to try to make sense out of conflicting information that exists on a given topic (conflicts cannot always be easily resolved, of course, but sometimes they can be when it turns out, for example, that one study has been soundly designed, implemented, and reported, whereas another is based solely on the author's opinion or on anecdotal evidence); (2) to develop an agenda showing clearly where the gaps in needed information are that call for new agency research; and (3) to lay the groundwork for further GAO evaluation or audit work in the area.

In using the information synthesis approach, we do not expect to propose any agency action, other than the filling of important knowledge gaps our work has revealed. Therefore we make no recommendations, contrary to the procedure we would use in a methodology featuring original data collection, such as an effectiveness evaluation or an economy and efficiency audit. However, we do make conclusions and observations about the information we have found and to

do this naturally entails the prior elaboration of a synthesis framework laying out the questions and subquestions to be answered, the scope, nature, and time-frame of the initial literature review, and the criteria for assessing the quality of the information. If you look at our report, you will see that we have documented this important front-end work in considerable detail.

A potential problem in such an approach might be the question of the "universe": that is, how can we be sure we've got all the major studies? In this case, although it was an especially arduous task to accomplish--given the breadth, international character, and classification of the topic, and the obscurity of some of the work--we now feel assured that we have covered all the major studies done as of May 1982 (end-date for our data collection effort). One of the methods we use in the synthesis approach to reach this assurance is through the combined knowledge of a panel of experts. (In this case, we included DoD's General Niles Fulwyler and Dr. Amoretta Hoeber. The OSD focal point position was not filled at that time, as you know.) We were further confirmed in our confidence by peer reviews of our work (including the CIA) and our January 24 session with your staff in which no title, document, or source was produced that GAO had not already reviewed and analyzed.

With regard to the potential benefits of the synthesis approach, we feel they are enormous. First, the ability to draw on a large number of soundly designed and executed studies adds great strength to the knowledge base when findings are consistent across different studies by different scholars using different methods. No single study, no matter how good, can have this kind of power. Second, when studies are not well designed and executed, the knowledge that there exists no firm basis for action is also an important benefit: the size of the risk is clarified, necessary caution is introduced into the debate, and over the long term, the number of failed shots in the dark is likely to be diminished.

I hope this letter will better explain what we are trying to do and how it differs from an audit or literature review. A GAO staff paper describing the synthesis methodology may be of additional help. Please let me know if you would like to see it.

With kind regards,

Sincerely yours,

Eleanor Chelimsky
Director

(973544)

END

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